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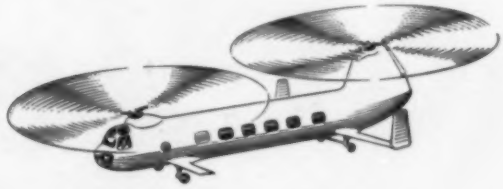

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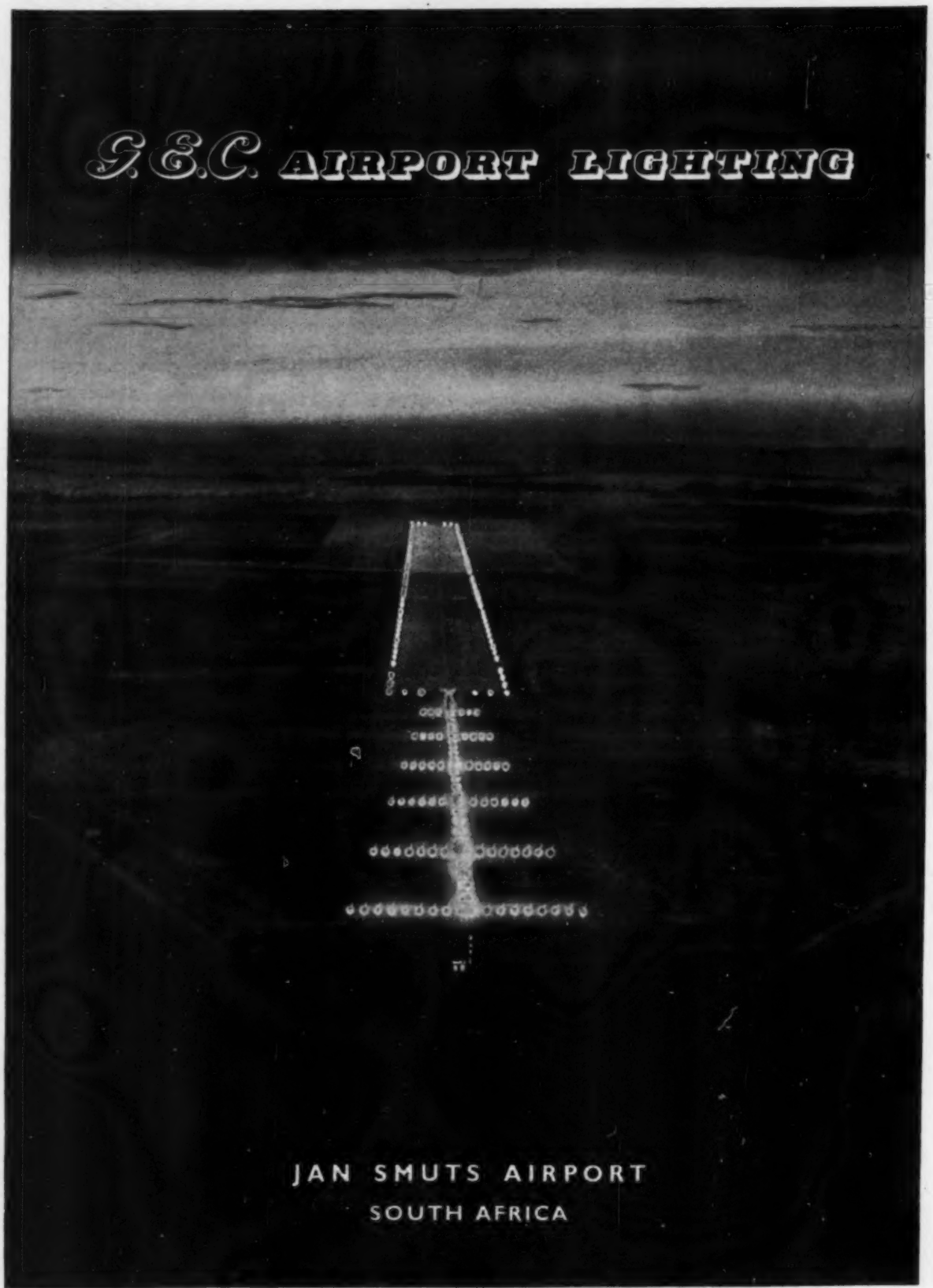

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and
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Balance Sheet

LET us assume that in the next few weeks our canny Chancellor will allow our overseas flag-carrier to spend, say, $60 million on a dozen or so of the big American jets. When he does this the American industry will move just that little further ahead as the world's suppliers of this class of transport, while the British industry's prospects in this field will recede just that little further. This, many will say, is deplorable; it should never, the Blimps will declaim, have been allowed to happen.

Yet we wonder whether it will not, in fact, be for the best. About a year ago, the country indulged in some heart-searching over its aircraft industry. A lot of money had been wasted, and the conclusion was reached that resources were too thinly spread over too many projects. Let us, it was argued, build fewer aircraft—but build them superlatively well.

This policy now seems (partly by reason of good luck) to be paying off. The Chancellor is certain to be able to replenish his dollar-coffers to the tune of some $180 million (80 per cent of it into the U.S.A.) for Viscounts, Comets and Britannias sold into the dollar market; and much of the sting is taken out of our loss of the big jet-liner business by the fact that Rolls-Royce are likely to make many millions of dollars from Conway, Avon, Tyne and Dart sales.

The good luck was the change in world standards as to what constitutes a medium-haul airliner. The DC-8 and 707 brought the Comet, Britannia and Vanguard into sharper focus as medium-haulers. Fashions often change quickly in aviation, but it was no luck that the industry was quick to cash in on its new opportunity. De Havilland gave Capital what it wanted; and Bristol—just in case any American operator might be wavering over the Electra—are in the States right now with a Britannia, offering delivery 18 months ahead of Lockheed. They hope to sell 50, and may well do so. Vickers, meanwhile, pull in U.S. Viscount repeat-orders and are following up hard with the Vanguard.

There, then, is the balance sheet; and it must be remembered that the market for medium-range airliners is many times the size of the big-jet market. And while the latter is half-saturated, the former is still opening up.

Best of Two Worlds

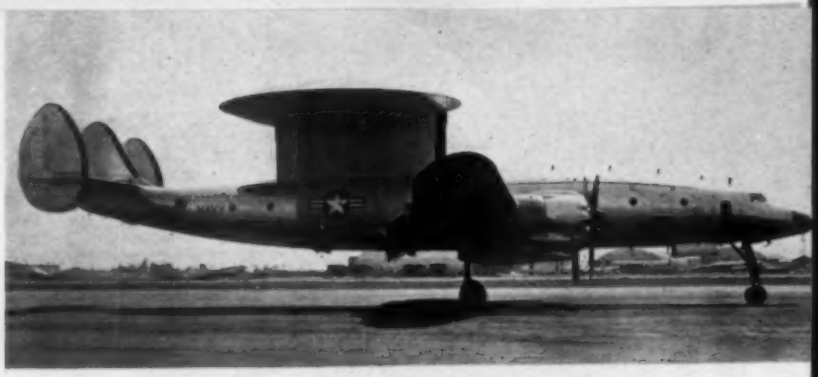
ELSEWHERE in this issue is a progress report on the Fairey Rotodyne. Many people have tended to regard this ambitious aircraft as "another grandiose British idea which will never come to anything." Recently we were privileged to learn much of the work which The Fairey Aviation Company have done on this programme and we have been singularly impressed by their policy and outlook. It now seems clear that unless there is some hidden snag which has so far eluded the most thorough investigation the Rotodyne may be made by the hundred. It is not just a big helicopter but the precursor of a wholly new sort of vehicle combining the best of both fixed- and rotary-wing worlds in an unique combination of qualities.

These abilities can be stated quite simply. It will meet civil airworthiness requirements, with single-engine safety; it will operate from any clearing 400ft by 200ft; it will carry 40 to 50 passengers or upwards of five tons of cargo, including vehicles; it will cruise as fast as a DC-3; and its direct operating cost should match those of the best fixed-wing aircraft.

Such a paragon may generate suspicion, yet it would be difficult to pick holes in the Fairey philosophy. Almost the only question which can be raised is that of noise, and the company are already demonstrating that they have a solution.

Four such vehicles could handle all present passenger traffic carried by public transport between London and Edinburgh. They could do startling things on the cross-channel routes with either passengers or vehicles. Between Tasmania and Melbourne they could double the already huge traffic in fresh fruit and vegetables and they would be ideal in working the airfield-starved islands of the West Indies or at serving such frontiers of industry as are met in British Columbia.

FROM ALL QUARTERS



CAPPING EVERYTHING: Described as being still in an experimental stage is this fantastic disc-shaped radome, mounted above a Lockheed WV-2 Super Constellation of the U.S. Navy. Tests at Edwards Air Force Base are to take place shortly (see news item below).

To and From Suez

AIRCRAFT from R.A.F. Transport Command and the airlines—including B.O.A.C.'s Britannias—have been heavily engaged flying troops to and from the Mediterranean area, and civilians away from Suez. A fair share of the airlift—largely under co-ordination by Airwork—has fallen to the independent operators.

Three of the Britannias which are scheduled to join B.O.A.C.'s regular services in October flew from Hurn, Hants, last Sunday each converted to carry 100 soldiers.

Other troops flew out from Hurn and Blackbushe in Hermes and Viking aircraft, while Yorks were used to carry heavy baggage. Meanwhile, elements of the 1st and 3rd Battalions, the Parachute Regiment, were flown home from the Mediterranean by Hastings of Transport Command for further training; and three Solents of Aquila Airways (leaving two for the company's normal services) are to fly wives and families of Suez Canal employees from the Great Bitter Lake to Malta.

The Government's request for help in troop-lifting to the Mediterranean has met with a good response from the independents, and about 200 aircraft—about half of them four-engined—could be impressed if necessary.

Many of the four-engined aircraft (Hermes and Tudors) are already utilized on troop charter; Airwork, whose Hermes are regularly used for trooping anyway, could probably make some Vikings available without affecting their Safari and other services. Silver City, recently doing record car-ferry business across the Channel, take the phlegmatic view that should conditions become so serious as to require the use of their 22 Freighters and Superfreighters, holiday traffic would probably have declined anyway.

Crusader Speed Record Attempt

THE first American attempt to beat the world speed record set up by Peter Twiss in the Fairey Delta 2 last March was to be made over China Lake, near Los Angeles, this week with the Chance Vought F8U-1 Crusader. The name of the pilot has not been announced. The Crusader is reported to have recorded a speed of 1,100 m.p.h. in two runs last December. To beat the British record by the necessary one per cent it will have to attain at least 1,143.3 m.p.h. The Crusader is powered by a Pratt and Whitney J57 with afterburner and the record aircraft is now positioned at the U.S. Navy air base at Inyokern, close to China Lake.

German Orders

THE West German Government has recently confirmed aircraft orders from two British companies amounting to £7 m., and informed a third company that a contract "worth several millions" will be signed in the near future.

Largest of the German orders, said to be worth over £5 m., has been placed with Sir W. G. Armstrong-Whitworth Aircraft, Ltd., and is for 68 Mk 4 Sea Hawks. The second confirmed order, worth £2 m., is for sixteen Gannets from the Fairey Aviation Co., Ltd. Both orders include spares and equipment.

Meanwhile, Bristol Aircraft, Ltd., has been notified by the Federal German Ministry of Defence that the Sycamore has been selected for service with the German Defence forces and "a substantial number" will be required.

Engine Change

WHEN Lufthansa announced their order for four Boeing 707-320s on April 24, they stated that the aircraft would be "powered by Pratt and Whitney JT4 [J75] jet engines, equipped with Boeing-developed sound-suppressors and thrust-reversers." Last Monday, a surprise announcement from Rolls-Royce showed that the German airline had changed its mind: "Lufthansa have chosen Rolls-Royce Conway by-pass turbojets to power their fleet of four Boeing 707 jet airliners . . ."

Lufthansa apparently made their decision after a long and detailed evaluation of the performance of all the alternative engines and service facilities offered by each manufacturer. The airline states that some of the factors which influenced it were, (1) The Conway is lighter, giving the 707 an additional 5,700 lb of payload, or alternatively the same weight of extra fuel, (2) The Conway has a lower specific fuel consumption, (3) A slower jet efflux results in less noise, and (4) Reduced fire hazard, due to the surrounding "envelope" of cool air.

Curious Constellation

DESCRIBED as "looking like a flying saucer that has captured an aeroplane," the Lockheed Aircraft Corporation's new early-warning research aircraft (a development of the WV-2 which the U.S. Navy already operates) is now being tested at Burbank.

Basically a Super Constellation, the aircraft has (according to its manufacturers' description) "been made bizarre by a huge, discus-shaped structure spreading over it like a parasol. This ellipsoid, measuring more than 30ft across, is a radome which houses the experimental craft's distance-determining radar antenna."

First tests are by high-speed taxying to evaluate the aerodynamic characteristics of the big radome and its effect, if any, on stability and control. It will then be detached and sent by road to Edwards Air Force Base, where the WV-2 is due to undergo flight testing with all its special equipment in place.

Fairey Managing Director

LAST Monday, August 13, certain executive changes were announced by the Fairey Aviation Co., Ltd. Sir Richard Fairey, M.B.E., Hon.F.R.Ae.S., resigned office as managing director on August 10, 1956, but remains executive chairman. Mr. Geoffrey W. Hall, A.F.R.Ae.S., formerly an assistant managing director, has been appointed managing director. Mr. L. Massey Hilton, D.F.C., A.F.C., A.F.R.Ae.S., having intimated that on medical advice he would be obliged to seek early release from his executive duties, has resigned as assistant managing director but remains a member of the Board.

SAMPLING THE SHACKLETON: A visitor to Woodford on August 9 was Air Marshal Sir Bryan Reynolds, A.O.C-in-C., Coastal Command. Here, before a Shackleton flight on that occasion, are (l. to r.) Mr. E. Golitzine (Avro sales manager), Air Marshal Reynolds, Mr. J. A. R. Kay (Avro general manager), S/L. J. B. Wales (Avro test pilot), S/L. V. S. Swain (P.S.O. to the A.O.C-in-C.) and G/C. E. C. Dearth, Ret. (Avro security and R.A.F. liaison officer).

Mr. Geoffrey Hall first joined the company in 1925 as a 19-year-old apprentice. In 1928 he went to Rolls-Royce, Ltd., where he became an experimental test and development engineer and was closely connected with work on the "R" type engine for the Schneider Trophy aircraft. (Twenty-seven years later he was to lead the team which gained for Great Britain the current world's speed record of 1,132 m.p.h. with the Fairey Delta 2.) In 1932 he rejoined the Fairey Aviation Company and successively held appointments as flight development engineer, assistant chief engineer, chief development engineer, chief research engineer, and manager of the research and armament development division. In 1949 he was appointed the director in charge of engineering for the whole company, and in January 1955 assistant managing director.

Mr. Hall learned to fly with the London Aeroplane Club at Stag Lane in 1928, and holds a current licence. In 1946 he completed a helicopter course and flew solo on the Sikorsky R-4.

***FOR ASSAULT:** In this first published view of the Fiat G.91 light ground-attack aircraft for NATO, which made its initial flight last Thursday week at Turin/Caselle, judicious airbrushing by Fiat has hidden details of panelling, armament and wing section. Jigging has been set up for a pre-production batch of 27 of these Bristol-Orpheus-powered aircraft. General layout is reminiscent of the F-86D.*

An S-58 in England

FOR the aeronautically minded visitor, if not for the general public, the outstanding item at the Lee-on-Solent R.N. Air Day—reported on p. 269—was a demonstration of a Sikorsky S-58, the first to come to this country. It arrived at the end of June, and has since been at Lee-on-Solent and at the Yeovil works of Westland Aircraft, where it is to be used for trials with a Napier Gazelle free-turbine helicopter engine. This will form part of the development programme of the Westland Wessex.

The company's chief test pilot, W. H. ("Slim") Sear, flew the S-58 at Lee-on-Solent. It was finished in F.A.A. helicopter colours—dark grey upper surfaces, and light grey below—and bore the Naval serial XL722.

With the 1,525 h.p. Wright Cyclone (about twice the power of a Whirlwind's usual unit) emitting a smooth, even roar—the sound was quite un-helicopter-like—Sear first demonstrated some high speeds, steep turns and general manœuvrability, his most spectacular evolutions being zooms at an angle that looked steeper than 45 deg. Then he made a vertical (fuselage horizontal) climb to about 2,000ft, the helicopter going up like a high-speed lift. From this he descended in autorotation, simultaneously side-slipping steeply to right and left.

By comparison with, say, the Whirlwind, the S-58 is a shapely aircraft, and it is this, perhaps, that gives the illusion of its being far smaller than it actually is (fuselage overall length is 47ft 2in, and the diameter of the four-bladed rotor 56ft). At Lee-on-Solent one was suddenly made aware of its real size when, taking part in the setpiece "battle," it landed and disgorged 18 fully armed Marines. (Useful load is, we believe, over 5,000 lb.)

The S-58's speed capabilities are underlined by a report from Washington last week, which said that the U.S. Army was claiming three helicopter world speed records with an S-58 (Army designation H-34): 141.9 m.p.h. over a 100-km closed circuit (62.137 miles); 136 m.p.h. over 500 km (310.685 miles); and 132.6 m.p.h. over 1,000 km (621.37 miles).

World Parachuting Championship

THE Third World Parachuting Championship took place at Tushino aerodrome, Moscow, between July 29 and August 4. Altogether, ten countries including the United States competed in what was the most difficult competition yet held.

The competition consisted of four different tests. The first was a jump of 600 m (1,965ft) with immediate parachute opening and a spot landing. Second was a jump from 1,500 m (4,850ft) with free fall in a swallow-diving attitude for 20 sec followed by a spot landing. Third was a jump from 2,000 m (6,515ft) with two figure-of-eight flat turns during the free fall, followed by parachute opening at 30 sec. The final test was a team jump in which each team attempted to group their landings as close as possible to the centre of the ground marker cross.

The general standard of parachuting was extremely high, and many of the competitors actually landed with their feet on the cross. The parachutists were required to make two jumps in each part of the test, and the Czechoslav girl Jozefa Maksova averaged 3.28 m (10.75ft) from the centre of the cross for her jumps from 600 m.

Parachutists flew with their own pilots in Russian AN-2 biplanes, and each aircraft carried a Russian pilot in the second seat. Visiting competitors reported that this aircraft—used in the U.S.S.R. for many purposes—proved ideal for both static-line and free-fall parachuting.

On the final day of the competition, Russia, which had been leading up to this point, became the victim of a sudden change of wind direction, which landed the Soviet team outside the scoring area. Czechoslovakia—hard on their heels—now went ahead to gain five of the first six places for the men's individual class, first place in the women's class and the first team position. Final results were:—

World Champion, Gustav Koubek, 1701.6 points; 2nd, Leopold Ozabal, 1688.3; 3rd, Jaroslav Jehlicka, 1666.4.

Women's Individual Championship.—1st, Jozefa Maksova (Czechoslovakia), 1726.1; 2nd, Valentina Seliverstova (U.S.S.R.), 1716.7; 3rd, Galina Mouchina (U.S.S.R.), 1646.7.

Women's Teams.—1st, U.S.S.R.; 2nd, Czechoslovakia; 3rd, Bulgaria.

Men's Teams.—1st, Czechoslovakia; 2nd, U.S.S.R.; 3rd, Bulgaria.

***THE NEWEST THING** in American private-owner twins is the Beechcraft Badger, which cruises at about 200 m.p.h. on the power of two 188 h.p. Lycoming engines. First deliveries should be made next year.*

Hypersonics Anonymous

FROM New Orleans, in a report of a speech there by General D. R. Ostrander, director of development at the U.S.A.F. Air Research and Development Command, comes the first "inside" news yet given of Lockheed work on the so-called I.C.B.M. (intercontinental ballistic missile) development programme.

General Ostrander mentioned a new "hypersonic" missile produced by the Missile Systems Division of Lockheed Aircraft Corporation, describing it as a vehicle for research into the problems of bringing the I.C.B.M. back into the earth's atmosphere from outer space.

Within seconds of the rocket-powered device being fired, the missile (its name has not been revealed) will pass out through the earth's atmosphere and penetrate the isnosphere. After reaching an undisclosed maximum altitude it will fall back into the atmosphere, carrying data which will help to determine the suitability of various types of airframe structure, and the best shapes for the nose.

FOUR OUTSTANDING ISSUES OF "FLIGHT"

TWO years ago we first introduced a special number of *Flight* in which the scope and achievements of the aircraft industries of the British Commonwealth were reviewed and illustrated. The issue, and another which followed it last year, was welcomed both at home and overseas, and it will be repeated this year. This greatly enlarged number, forming a valuable means of reference to aircraft and component firms in Canada, Australia and other areas, will appear next Friday, August 24. It will be appropriately followed by the annual Britain's Aircraft Industry Number (August 31)—the biggest yet published—and then by the Farnborough Report and Farnborough Review issues.

BY BEVERLEY TO WILDENRATH

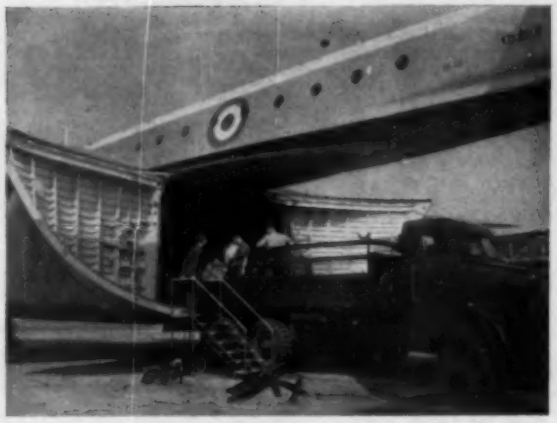
Blackburn's "Gentle Giant" Flexes His Limbs on a Daily Workout

ON Wednesday, August 8, at 0826 hr, Beverley C.1 XB 284 (known locally as Mike Oscar Bravo Xtra Hotel, of No. 47 Squadron, R.A.F. Transport Command) took off from Abingdon, Berks, for R.A.F. Wildenrath in Germany, captained by F/L. J. M. Earland and with S/L. D. P. Boulnois, the squadron commander, aboard as route-checker. Within the Beverley's capacious hold was 29,600 lb of freight, nearly all of it in packing-cases, the heaviest items being three Avons and two car engines. In the upper compartment were nine passengers, including the writer: the Air Ministry was making it possible for us to see the Beverley operating this daily out-and-return freight service, five days a week, which forms part of its trials.

During the 1 hr 55 min outward flight there was ample opportunity for looking round the inside of the aircraft, asking questions about it and discovering the crew's opinions.

The aft compartment, where we were well looked after by the air quartermasters, can seat 36 with good visibility and ventilation, and provision for a public address system. Two upward-opening trap-doors at the rear provide a ground entrance and exit (*via* steps about 17ft high) or an air exit for paratroops. Two hatches at the forward end lead down to the cargo hold (which for troop-carrying can seat 58), and progress through it to the flight deck was by a series of precarious footholds on packing-cases, rather resembling Alpine climbing and carried out (on this flight) at much the same altitude. The hold itself, 10ft wide, 10ft deep and 40ft long, epitomizes the Beverley's main advantage over the Hastings. Not only can it take three times as much; it can accommodate extremely bulky loads and the electrically operated rear doors enable cargo to be loaded and unloaded in about two-thirds of the time.

There seemed to be general satisfaction among the crew with their compartment, except on the score of noise and vibration (particularly for the navigator and signaller, who are in line with the airscrews) from the four Centaurus; but apparently there is to be a remedial modification. There is ample room for the normal crew of four (two pilots, navigator and signaller) and everything seems to be neatly installed. For the pilots, flying will require less concentrated effort when an autopilot is fitted, though the fully-powered controls require only very light stick forces.



Traditional method—by lorry and man-power—of unloading the Beverley, which has its freight doors fully opened.

No occasion arose on either journey for asymmetric flying, but, provided it is possible to feather the failed engine, the Beverley proceeds quite happily on three. Recently S/L. Boulnois took off on three in an aircraft which had force-landed with a windmilling airscrew.

Before we left on the return flight, and while the last of an even bulkier (though slightly lighter) load was clamped down in Mike Oscar's hospitable inside, S/L. Boulnois spoke of the Beverley's intended functions and its fulfilment of them.

There had been a "joint requirement" for an aircraft which could go, say, 250 miles with 300 troops and land in a small area; or could fly in a body of troops plus a Centurion or a Scorpion. Such roles are being tried out, but already the aircraft has landed with 92 soldiers (most of whom had never flown before), disembarked them and taken off again, all in the space of 4½ minutes.

From the flying point of view, S/L. Boulnois said the aircraft was well liked. The squadron had had no trouble converting, though only a few of its crews had previous four-engine experience. (It may be mere coincidence, though a happy one, that 47 Squadron was formed at Beverley, Yorks, in 1916.) A fine feather in the squadron's cap was the transportation out to Cyprus, only six weeks after they had received their Beverleys, of three Sycamores and a Whirlwind within a period of eight days.

Thus fortified with information, we clambered up the steps into our lofty eyrie for the return journey, which was as smooth and uneventful as the outward one but took 2 hr 23 min, owing to headwinds and a practice BABS approach at Abingdon.

But how very much quicker this is than sea-and-rail freight transport becomes clear when one recalls that Tilbury - Hamburg takes 24 hours and Hamburg - Wildenrath anything up to three days.

Watching the landing from behind the pilots, one had a good view of the forceful effect of the four Centaurus in full reverse. We seemed to come to a stop in well under 300 yd—another of the Beverley's valuable operational characteristics.

And for this comfortable introduction to the qualities of Britain's "gentle giant"—to use with full approval the happy phrase of *Flight's* leader on June 29—we were much indebted to the genial and helpful members of No. 47 Squadron.

The ways of getting in—by vertical loader (left, above) to the rear fuselage and (below, left) step-by-step for the passengers. Below, crew comfort, showing (left) F/L. Earland doing a pre-flight instrument check and (right) M.Sig. J. B. Browne and F/L. M. J. Marsh (signaller and navigator) discussing a point in their adjoining seats.

SUSTENANCE for a McDonnell F2H Banshee fighter of the U.S. Navy is provided here by a Convair R3Y Tradewind flying-boat of the same Service equipped as a tanker. It can refuel up to four jet fighters in less than five minutes and carries sufficient fuel to service eight fighters.

HERE AND THERE

"H.P." Honoured

IN the *London Gazette* for August 10 it was announced that the Queen had appointed Sir Frederick Handley Page, C.B.E., as Lieutenant of the County of Middlesex. He succeeds Baron Charles Latham, who has resigned. Sir Frederick, who is 70, was formerly Deputy Lieutenant of Middlesex. One of the best-known figures in the British aviation industry, he founded Handley Page, Ltd., in 1909.

Unmanned Photography

FROM Holland comes a report that the third Aviolanda AT-21 target aircraft is almost ready. One of its alternative functions will be tactical photography. The power unit is a S.N.E.C.M.A. "resonant duct" of 190 lb thrust.

Agricola for New Zealand

THE second Agricola, ZK-BMJ, was test-flown on August 7 by Auster chief test pilot Ranald Porteous. The first of these aircraft to be dispatched to New Zealand, it is being dismantled and crated for shipment.

Long-range Warrior

IN Washington the U.S. Navy reported recently that a Douglas A3D Skywarrior had flown 3,200 miles non-stop from Hawaii to Albuquerque, New Mexico. This is believed to be an unofficial record for a modern carrier-based jet aircraft.

Professor-Ship

THE U.S. Air Force has placed a T-33A at the disposal of 67-year-old Professor Walter Georgii, who is making a special study of high-altitude jet streams. The U.S.A.F. base at Furstenfeldbruck, near Munich, has been instructed to help him, and NATO officials in Paris believe his meteorological investigations may produce important results.

S.B.A.C. Scholarships

THE S.B.A.C. has announced the award of second-year scholarships at the College of Aeronautics to the following: E. M. Cowburn, E. R. Kendall, A. Lawson, J. A. Leitch, D. M. Squires and D. J. Stewart. The following have been awarded the 1956 university scholarships: A. H. Atkinson and R. R. Grenyer (Hawker Aircraft, Ltd.); D. R. Wilson (D. Napier and Son, Ltd.,); R. Tetlow (A. V. Roe and Co., Ltd.,) and C. M. Darby (Rolls-Royce, Ltd.).

R.Ae.S. Cranfield Award

THE Royal Aeronautical Society Prize in Aeronautics at the College of Aeronautics, Cranfield, has been awarded to J. R. Hatfield, as the best student of the year in the 1955-57 diploma course.

Brighton Helicopter?

PROVISION for helicopter landings may be provided in a £3½m scheme for rebuilding Victoria Station, London. The scheme, which has been sent to the L.C.C. for planning permission, involves a hotel, an office block and a parade of shops.

Third Hiller for Hamble

FROM Hamble comes news that Air Service Training, Ltd., hope to expand their helicopter training facilities in September, when they expect to take delivery of a new Hiller 12C. A.S.T. already operate two 12Bs modified almost to 12C standard.

S.L.A.E. Lecture

THE annual "Farnborough Show" lecture of the Society of Licensed Aircraft Engineers is to be given by W/C. G. H. Dhenin, A.F.C., G.M., B.A., M.B., B.Chir., M.R.C.S., L.R.C.P., of headquarters, Bomber Command, R.A.F., on "Protection against radiation hazards in aviation." It will be in the R.A.E. main assembly hall on September 3 and admission is by ticket only obtainable from the S.L.A.E. secretariat at 1 High Street, Maidenhead, Berks. (Maidenhead 3621.)

Sud-Est Aviation

FROM August 28 the French aircraft company S.N.C.A.S.E. will change its name to Sud-Est Aviation, Société Nationale de Constructions Aéronautiques. The company's Paris address will be changed on the same date to 37, Boulevard de Montmorency, Paris XVIe, telephone number Bagatelle 84-00.

"Big Six Decade"

AN error in transcription in the opening sentence of last week's article "Big Six Decade" made it read that the prototype DC-6 was undergoing its flight trials ten years ago last August; but as other dates in the article indicated, this should, of course, have read "ten years ago *this* August."

Executive Friendship

FROM America it it reported that the General Tyre and Rubber Company has ordered a Fairchild-built Fokker Friendship for executive use. The first company to order a Friendship for such a purpose, it already operates six multi-engined aircraft on business.

Heavyweight Extraction

THE U.S.A.F. and Lockheed Aircraft Corporation report that what is claimed to be the heaviest single load ever dropped by parachute from an aeroplane, was "extracted" from a C-130A Hercules during dropping tests at El Centro, Cal., Naval Auxiliary Air Base. Suspended from six 100ft parachutes, it consisted of 27,000 lb of iron.

Bell Museum

AT Baddeck, Nova Scotia, Canada, the Alexander Graham Bell Museum is to be opened to the public tomorrow, August 18. Established by the Department of Northern Affairs and National Resources, it commemorates Dr. Bell's researches in powered flight, particularly those with his associates of the Aerial Experiment Association at Baddeck between 1907 and 1909.

REPORT ON THE ROTODYNE

The World's Most Versatile Large Helicopter

FOLLOWING the commendable, but rarely practised, precept of saying little until they can speak with assurance, the Fairey Aviation Company are now prepared to reveal in some detail the remarkable aircraft known as the Rotodyne. Some of the potentialities of this ambitious machine are discussed in a leading article in this issue.

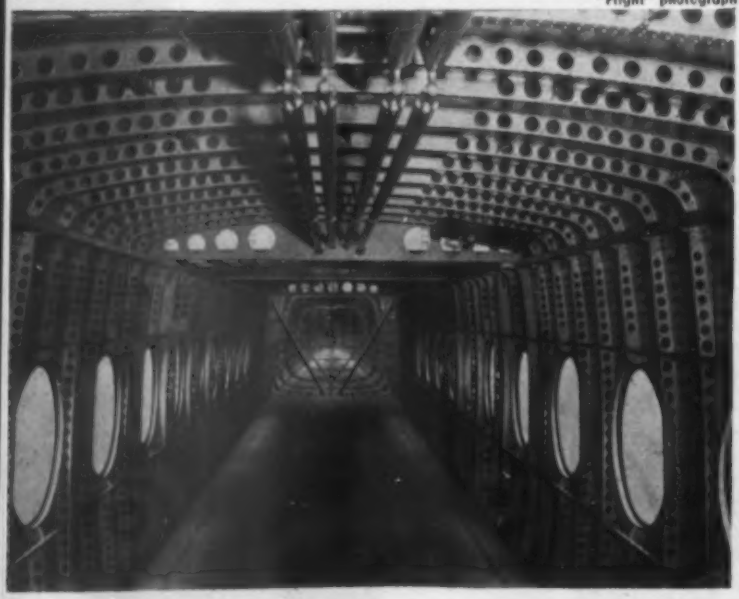
Helicopter development at Hayes began a decade ago, and attention was early concentrated upon the Gyrodyne principle, in which a conventional airscrew provides forward propulsion and balances the torque of the rotor. Two Gyrodynes were built, one gaining a speed record for helicopters in 1948. Both employed a mechanical drive from an Alvis Leonides piston engine, but, looking far ahead, Fairey became increasingly interested in tip-drive schemes, using compressed air or gas along lines, which are today generally recognized as the only practicable methods of driving very large rotors. During investigations of a number of configurations for a large, turbine-driven machine, the present Rotodyne layout asserted itself as virtually inevitable.

This layout comprises a single lifting rotor, a fixed wing and two airscrews driven by Napier Eland turboprops. Each Eland also drives an hydraulic clutch which, when filled with oil, turns an auxiliary compressor feeding fresh air to the rotor at 4 atmospheres pressure and at 160 deg C. The turbine exhaust gas is passed overboard. At take-off the airscrews are placed in zero-thrust pitch and nearly all the power is absorbed in supplying the rotor with air, which is used to feed kerosine-burning pressure-jets at the tips of the four blades. At a suitable height the pilot moves the cyclic-pitch lever forward to tilt the rotor axis and so cause the aircraft to move forward. At about 100 kt power is gradually transferred from the auxiliary compressors to the airscrews until the Rotodyne is cruising solely on the thrust of the latter, with the rotor autorotating. To land, the process is reversed.

This type of propulsion system was worked out in some detail, with close co-operation from Napier, before 1953. Fairey were one of the six firms who tendered to the "Bealine Bus" specification, but the first proper foundation was provided by a limited M.o.S. research contract awarded late in 1953. When it seemed certain that the company were really "on to something" the full go-ahead was given in the summer of 1954. It is worth noting that the contract specified no detailed requirements, and Fairey were given a free hand within the framework of the propulsion system already described and a stated gross weight. Nevertheless it was logical that the company should keep an eye on possible business and they have worked from the outset on a machine attractive to operators in many fields.

Three thousand unobstructed cubic feet, capable of rising and descending vertically and of flying level at 200 m.p.h., is surely a unique attraction. Linkages to the rotor hydraulics can be seen.

"Flight" photograph



One of the first design choices was how fast the Rotodyne should cruise. At first a figure of 130 kt was selected. This is appreciably faster than conventional helicopters and it was made possible by using the fixed wing to provide half the total lift in cruising flight. The resultant reduction in rotor angle of attack removes the danger of retreating-blade stall—the factor which usually imposes the upper limit on speed—and, as the rotor autorotates tilted backwards, lift is generated uniformly along the whole blade. Propulsive efficiency also gains, since, whereas airscrews can reach at least 85 per cent at moderate speeds, horizontal rotors are only about 50 per cent efficient in providing forward thrust.

Fully conscious of the magnitude of the programme, Fairey invested a great deal of their own money in research and test facilities to supplement the modest equipment used for the Gyrodyne. The Gyrodyne was also put to work, one being converted to pressure-jet drive with an air compressor driven by the existing piston engine. On the Fairey airfield at White Waltham, Berks, test rigs have been built with which the propulsive system has been taken to a high state of development. Tip jet units have been extensively bench tested in former engine-test cells and complete Elands, with the correct length of piping, have been run throttled to give the proper pressure ratio for single jet-nozzles. Other jet units have been run on a whirling arm, supplied with air from an Eland or Dart, to check mechanical strength and air distribution. Fairey now have no qualms about getting the right rotor power.

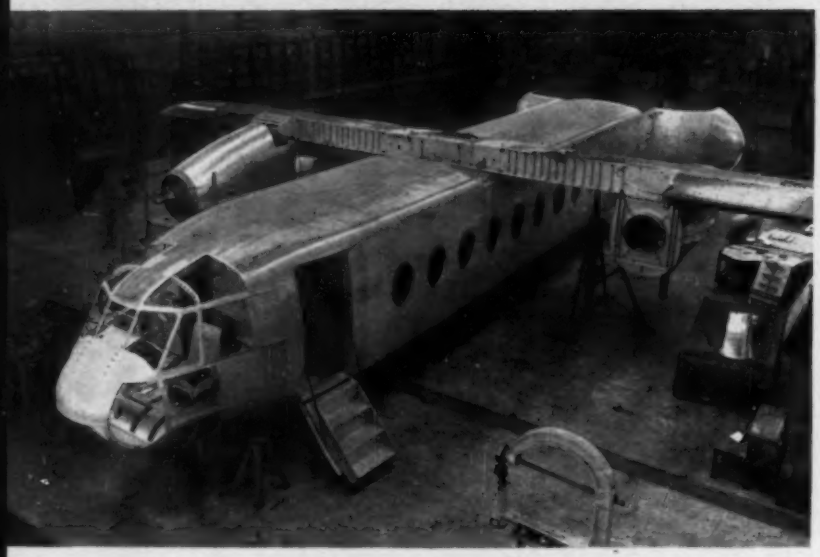
Tunnel testing has been carried out in an almost ideal facility, with a 12ft by 10ft working section going up to 200ft/sec. With this tunnel large models have been run, chiefly at about 160ft/sec, with the rotor turning (a type of test which has not been announced by any other manufacturer in the world). Two years of Gyrodyne flying has shown that there are no difficulties attending general flying—transition, in particular, has proved trouble-free—and that economical tip-jet thrust is quite possible, the Gyrodyne rotor having the same blade section as the much larger Rotodyne. The work has been handled almost entirely by the Fairey engineering department, under the general direction of Mr. R. L. Lickley, the chief engineer.

Manufacture of the first prototype is now at an advanced stage at Hayes, and additional parts have been made at the company's factory at Stockport. Fairey have been careful to treat the Rotodyne as "just another aircraft," and they seem to have achieved one of the best rotating-wing airframes yet. In fact it has been deliberate policy to keep all Rotodyne personnel in close touch with the company's fixed-wing designs, to ensure that the project never becomes a close-knit "black-magic" affair behind closed doors. Conversely, of course, Fairey's other projects have been able to learn much from the design of the big helicopter, and the company should be in a strong position when the time comes to build steel airframes.

Throughout, the keynote has been simplicity. The fuselage is a box, 8ft wide and 6ft high (in the first machine) with big clamshell doors at the rear end. The wing is a good, thick assembly with constant section from root to tip. The engines are neatly installed and can be pulled out by undoing four bolts. Rotor control is—putting it bluntly—by brute force, in the form of Fairey's own Hydroboosters. The Rotodyne airframe will certainly have a far lower percentage structure weight than that of any other helicopter.

One of the many troubles afflicting existing helicopters is rotor life. It is bad enough having to buy new blades for a small Hiller or Bell, but to ask operators to replace a giant 90-foot assembly, even every 1,000 hours or so, would be unreasonable. Accordingly, Fairey have taken the bold, and perhaps unprecedented, step of aiming at a rotor life equal to that of the rest of the airframe. The whole system is steel. Root fittings and head are machined from massive forgings in 90-ton steel and the blades themselves are stainless and should stand up well to bad weather. The tip jets are fed through three pipes anchored within the root of the lifting-aerofoil part of each blade (which starts about 10ft from the axis of rotation) and allowed to float axially within Fluon bushes. Chord is about 28in, and—like the rest of the airframe—the company's patented envelope-jigging principle is used.

Fuel for both the Elands and the tip jets is kerosine, housed in bags in the wing. Fairey designed and made their own undercarriage, which has twin wheels on each leg, hydraulically retracting into each nacelle. Although not a requirement, the gear is designed to accept 60-knot landing speeds (which, it is considered, should suffice for any emergency with one engine out). Landing will



At present Britain's only completely new helicopter project sponsored by public funds, the first Rotodyne should start ground running in about four months' time.

"Flight" photograph

normally be vertical, the view through the lower nose panels being perfect. Instrumentation is complete for all-weather operation, and ice protection will be incorporated on production machines. Handling difficulties should be very few. Rotor speed can be varied independently of the engine r.p.m. and it should be a straightforward job to evolve the optimum operating techniques. Yaw control at low speeds is effected by differential control of airscrew pitch by means of a special rudder-pedal linkage which fades out as forward speed is gained. General trim is provided by the elevators and (on the first machines, at least) by an aileron on the port wing.

The second Rotodyne, which was ordered a year ago and is now occupying jigs, will be rather longer and will also have a square-section hull 8ft deep. It will thus be able to carry heavier loads of certain types of freight and will be better able to utilize the increased power of later hot-turbine Elands. At present the standard unit is the E.151 Eland at the NEl.3 rating of 2,800 s.h.p. plus 500 lb thrust, with a dry weight of 2,350 lb. The second aircraft will start off with E.151s of NEl.7 rating of 3,250 s.h.p. plus 650 lb (3,500 e.h.p.) and later an E.151 version of the over-4,000 h.p. NEl.4 or 5 will be produced, with the effect shown in the table of data.

It is worth noting that the policy of Fairey has been, as far as possible, to keep plenty of aces up their sleeve. Thus, the rotor has been designed to the developed gross weight of 39,000 lb, and not to the 33,000 lb of aircraft No. 1; the cruising speed is now placed with assurance in the bracket 155-170 knots and not in the 130-kt regime originally envisaged; and, on the score of noise —which cannot be ignored with tip pressure-jets, particularly on a vehicle which could enter cities—a vigorous research programme has already lowered the sound energy by 10 db and promises to yield another 10, with a small thrust penalty. It is calculated that the take-off noise will be not worse than 95 db at 200ft—less than that of many existing transports. Furthermore, the very high rate of climb will rapidly take the Rotodyne above levels at which it could cause annoyance.

Owing to the size of the rotor the ground cushion is expected to be at least 100ft thick. Within it the Rotodyne is to be capable of single-engine hovering, and it should be possible to divert to alternate airfields at any time in the event of power failure. From the outset the design has been planned for full-load operation in the tropics, notwithstanding the difficulty of keeping down the oil temperature in hovering flight. The hull is not designed to be pressurized, since cruising height will not normally exceed about 5,000ft. It is partly as a result of low cruising height that, on many routes, the Rotodyne should be able to beat the times of faster, higher-flying fixed-wing machines.

A good operating platform for the Rotodyne is any flat clearing 400 by 200ft. For difficult operations autostabilization will be fitted and standard equipment will include all normal airline electronics. The unobstructed interior volume behind the flight deck totals 3,000 cu ft, not including the bulge inside the clamshell doors. Standard seat rails are provided for 10 or 11 rows of four seats at a pitch of 36in, in line with the large elliptical windows. Many types of interior have been planned, including configurations for several special purposes. At the front a large door, with integral steps, is fitted on the port side; used in conjunction with the rear doors it should cut ground time to a matter of very few minutes.

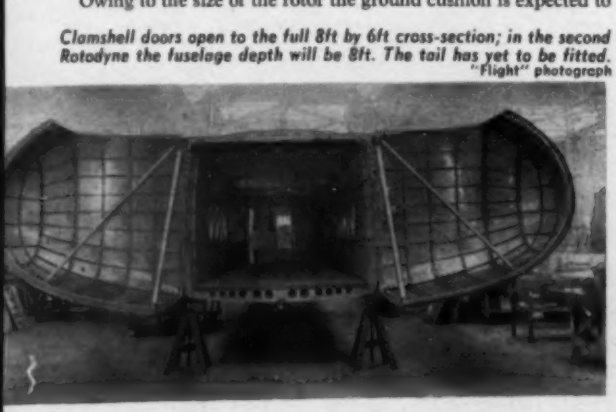
Comparisons are notoriously odious, but Fairey have done some quick calculations to see how their big whirler—it is, incidentally, the heaviest aircraft they have built—stacks up against existing machines. In relationship to present helicopters the Rotodyne's ability is such as to render comparisons quite ludicrous. For an example of this, it is possible to cite direct operating cost as a major criterion. Typical figures for a 100-mile stage are 17d per seat statute-mile for a good single-rotor machine, 14d for a larger, twin-rotor machine, and 2.8d for the Rotodyne (lower, incidentally, than the figure for any modern fixed-wing airliner); at 300 miles the figures are about 35d, 21d and 2.4d.

All this may smack of counting chickens before they are hatched; but this particular chicken is due to hatch at the end of the year, and it should fly early in 1957. Taking a broad view of the whole programme the outstanding thing is the boldness of Fairey—and, in view of the commitment of public money, the much-maligned Ministry—in doing the whole job at once, and not frittering away precious months in working up to it with scale models. Such boldness deserves to win a fine commercial reward and, if the Rotodyne does all that calculations indicate, it cannot fail to prove a best-seller.

W.T.G.

Clamshell doors open to the full 8ft by 6ft cross-section; in the second Rotodyne the fuselage depth will be 8ft. The tail has yet to be fitted.

"Flight" photograph



FAIREY ROTODYNE

First prototype, powered by two Napier Eland NEL.3 turbines rated a 3,000 e.h.p.—Span, 46ft 6in; rotor diameter, 90ft; fuselage length, 58ft 8in; track, 24ft 6in; overall height, 22ft 2in; gross weight, 33,000 lb; disposable load, approximately 40 per cent of the gross weight; typical payload, 40 passengers on a 90-mile stage or 30 on a 210-mile stage, or about 10,000 lb freight.

Second prototype, powered by two Napier Eland NEL.7 turbines rated at 3,500 h.p.—Dimensions as for first aircraft, except for an increased fuselage length; gross weight, 39,000 lb; disposable load, about 16,000 lb; typical payload, 40 passengers for a 460-mile stage with full allowances (I.A.T.A. recommendation, 40-50 for a 200-mile stage); direct operating cost, 2½d (3c) per seat mile (I.A.T.A. asked for 5c); cruising speed, over 170 m.p.h. (I.A.T.A., 150 m.p.h.); vertical rate of climb at maximum climb power, 1,670ft/min (I.A.T.A. requested 600 ft/min); and full single-engined safety.

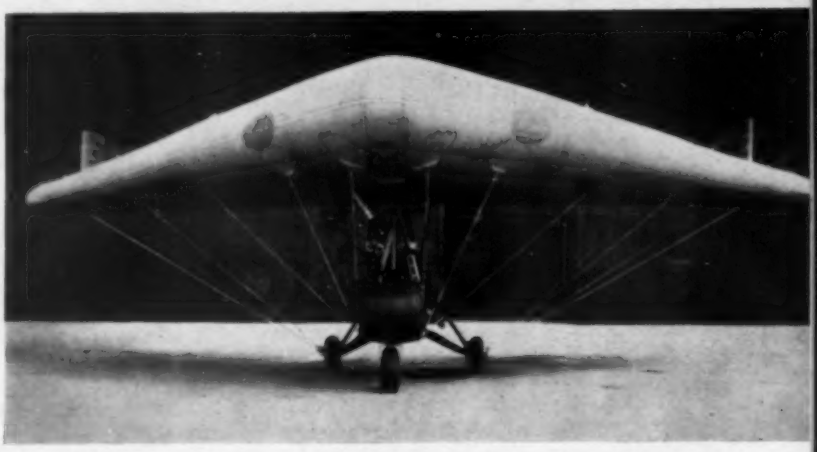
Developed Rotodyne with hot-turbine Elands rated at over 4,000 e.h.p.—As above, except that it will be possible to take 50 passengers on 430-mile stages with direct operating cost substantially below even that of earlier Rotodynes.

SPEEDY CONVERTIPLANE

THE U.S.A.F. Air Research and Development Command announced recently that the McDonnell XV-1 convertiplane had unofficially exceeded the speed record for helicopters by reaching 200 m.p.h.

This occurred when the XV-1 was being flown near the McDonnell Corporation's plant at St. Louis, Mo, on a flight-evaluation programme conducted by the A.R.D.C. Flight Test Centre. The pilot, Capt. W. W. Eggert, made 39 flights, in which five conversions were reported to have been accomplished from rotor take-off to forward flight, and back to rotor for landing.

McDonnell Aircraft Corporation has also announced that it has built and is already flying a second XV-1.



The new M.L. from two aspects. Note the improved appearance in comparison with the first prototype (below).

M.L. Mk 1

"Rubber Wing" Utility Aircraft in New Form

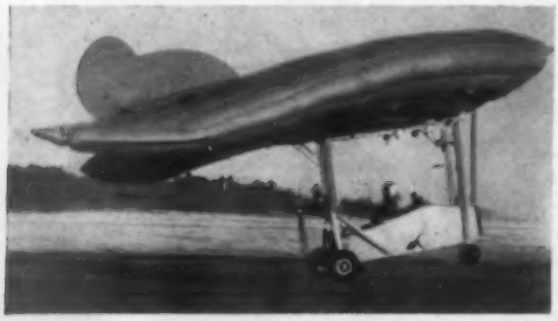
IT is now possible to publish photographs of the newest version of the highly unorthodox M.L. light aircraft, designed and made by M.L. Aviation Co., Ltd., of White Waltham, Berks. As will be seen, it differs considerably in appearance from the prototype of a year ago; certainly it no longer merits the disrespectful nickname "The Mattress."

The inflatable rubberized-fabric wing, of delta plan-form, has been very considerably cleaned up, and no longer presents the quilted appearance of the original. The basic structural method is, however, retained, the upper and lower surfaces being connected by a number of porous fabric diaphragms running spanwise and maintaining a symmetrical aerofoil profile developed from N.A.C.A. 0024. After initial inflation on the ground, the wing is maintained at its correct internal pressure—which is under 1 lb/sq in—by an electrically driven pump (this was previously windmill-operated) and a relief valve.

Control is by inflated elevons (combined ailerons and elevators) over almost the full span of the trailing edge; they are operated by cable from an inverted control column mounted on the fuselage superstructure. Vertical stabilizing surfaces are now fitted near the wing-tips; the central fin has been dispensed with.

The whole wing can be deflated and packed in a bag which, with the tiny fuselage, takes up very little space. The makers remark that it could be kept in the average domestic garage and should therefore appeal strongly to the private owner.

The wing is secured to the superstructure of the nacelle-type fuselage—or *vice versa*—by a series of toggles, and flying wires lead from patches on the wing under-surface to points on the fuselage and undercarriage members.



The prototype of a year ago.

It will be seen that the fuselage has now been completely redesigned, the box-like affair previously employed having given place to a much slimmer, longer structure with tandem seating for pilot (in front) and a passenger. The tricycle undercarriage, with swivelling nosewheel, now has its rear wheels mounted on legs instead of on a horizontal axle.

Whereas the prototype's pusher engine—a 65 h.p. McCulloch intended for pilotless aircraft—was mounted on a pylon, the power unit of the new Mk 1 machine is a Walter Mikron III in a cowling faired into the rear of the fuselage. Cruising speed has been increased from about 45 m.p.h. to 58 m.p.h.

A simple but presumably quite sufficient range of instruments is fitted: A.S.I., altimeter, engine r.p.m., oil pressure, wing pressure and compass.

The M.L. is the subject of a Ministry of Supply contract. When this was placed, the M.o.S. stated that it was "for the construction of a light, easy-to-produce and easy-to-pilot communications aircraft" for which both military and civil applications were foreseen.

M.L. LIGHT AIRCRAFT Mk 1
(Walter Mikron III)

Maximum speed (on 50 h.p.)	68 m.p.h.
Cruising speed (on 35 h.p.)	58 m.p.h.
Stalling speed	30 m.p.h.
Climb (sea level)	740ft/min
Take-off run	70 yd
Distance to clear 50ft	140 yd
Endurance (at cruising speed)	2½ hr
Ceiling	5,000ft
Dry weight	450 lb
Fuel (methanol/benzole/petrol)	85 lb
Pilot	180 lb
Passenger	180 lb
Baggage	40 lb
Total weight	935 lb
Span	35ft 0in
Root chord	17ft 6in
Tip chord	5ft 9in
Overall length	23ft 3in
Wing area	400 sq ft
Overall height	10ft 6in
Wheelbase	7ft 1in
Track	5ft 4in

"FLIGHT" PHOTOGRAPHS

MANY of the photographs reproduced in *Flight*, i.e., those taken by our own photographic staff (as indicated on publication) are subsequently available in the form of high-quality prints. Prices are as follows (dimensions given in inches): 5½×3½, 1s 4d (glossy or semi-matt, unmounted), or 2s (toned sepia, unmounted); 6×4, 2s 6d or 4s; 8×6, 3s 6d or 5s 6d; 10×8, 5s or 7s 10d; 12×10, 6s or 9s 8d; 15×12, 9s 6d or 13s; 20×16 (semi-matt only), 13s or 18s.

Also available are a postcard series, totalling over 200, depicting both historic and modern aircraft of the R.F.C., R.N.A.S., R.A.F. and Fleet Air Arm. Complete lists of the series are obtainable on application. Prices are 8d each card, or 7½d each for quantities of a dozen or more. One view only—in most cases a good three-quarter front or side—is available for each aircraft type. Also available as postcards, at the same prices, are reproductions of general-arrangement drawings of some 20 British aircraft that have appeared in our "Aircraft Intelligence" pages.

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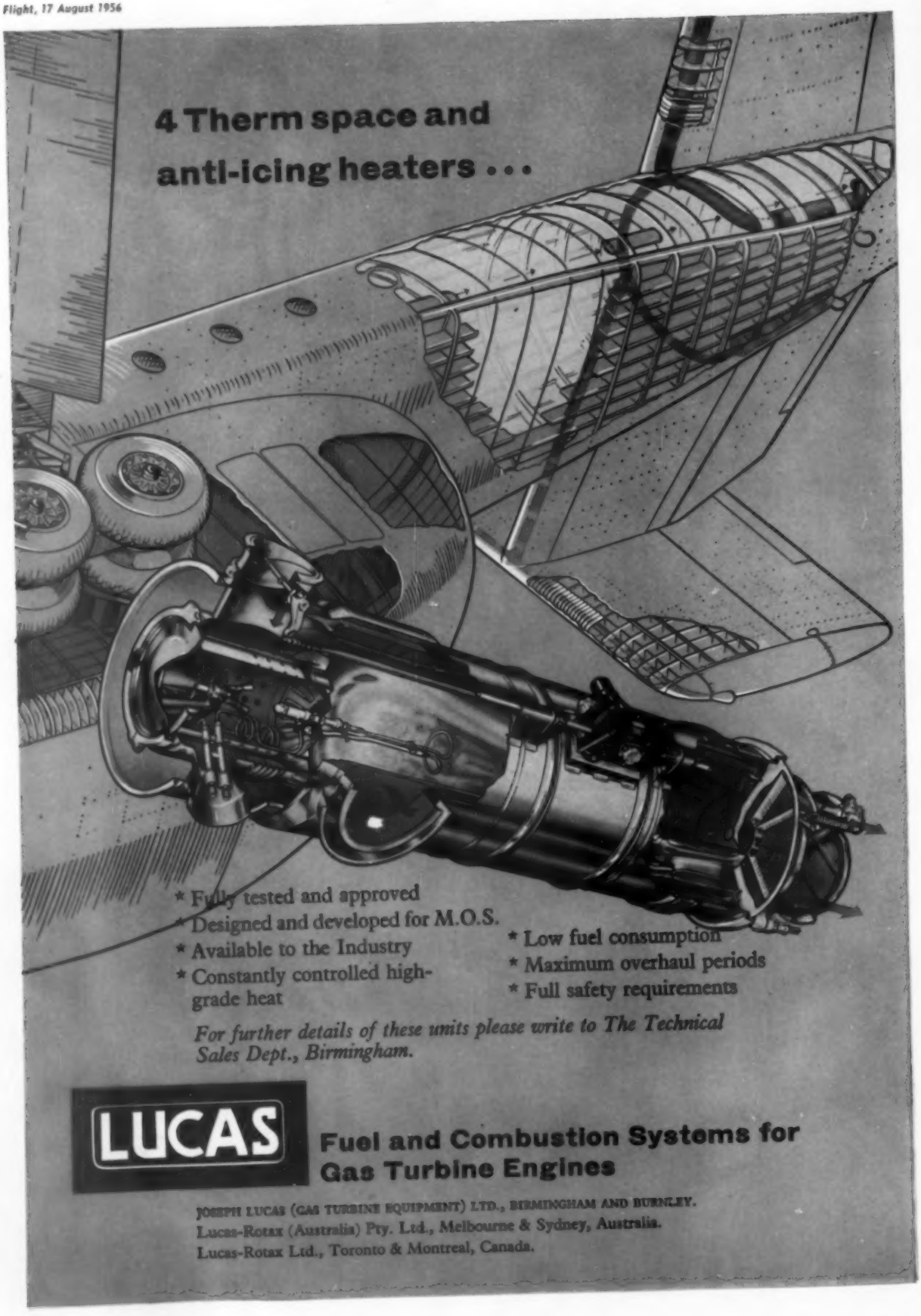
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Handling the Spanish Heinkel 111

A Memorable Flight in a World War 2 German Aircraft Type in Service Today

By C. M. LAMBERT

DURING a recent visit to Spain I had the opportunity of flying one of the Heinkel 111s being produced for the Spanish Air Force by C.A.S.A. in their Seville factory. The company has now built a large number of these aircraft under the designation C.A.S.A. 2.111, and is still completing many more. They are virtually identical with the German originals and I was interested for this reason to see what sort of a machine the 111 is—and was. The experience was the more interesting because this was no museum-piece left over from World War 2, but a brand-new machine which had only just been accepted by the Spanish Air Force; and also because the pilot on this occasion was one of the most redoubtable airmen it has yet been my good fortune to accompany in the air.

"Press on" was the key word for this flight, and we got airborne without pausing for anything so light-hearted as a gay laugh. I was driven by car on to the grass airfield at Tablada, just outside Seville, and taken right up to the aircraft and, while I was being introduced to Capt. P. Santa Cruz, the test pilot, and Capt. R. Gutierrez, his companion, an engineer was starting the two Junkers Jumo engines. This particular machine was a trainer, that is, the bomb bay had been replaced by two bench seats and full side-by-side dual controls were fitted. The bomb-aimer/front gunner's position and equipment were eliminated and no guns were mounted in ventral or dorsal positions. Equipment and layout are otherwise identical with the bomber version so that from outside bomber and trainer are virtually indistinguishable.

C.A.S.A. is also building the bomber version, which carries 4,400 lb of bombs upright in racks just aft of the flight deck. The front gunner lies on a couch on the starboard side of the completely transparent nose section to operate his gun—generally a Breda 12.7 mm, but sometimes a 20 mm cannon. The front end of the bed of the couch can be slid back to expose the bomb-sight and aiming window beneath it. Further versions in production are the reconnaissance bomber in which the starboard bomb racks are replaced by a vertical universal camera mount, protected underneath by sliding metal panels; and the command-transport version in which the gun blisters are eliminated and airline standard accommodation provided for nine passengers and a crew of four. Only 15 transports have been built.

For my flight we all climbed in through the ventral blister and walked forward to the pilots' compartment, where Santa Cruz took the left seat and I the right. The others stood behind us. Without pausing for anything at all Santa Cruz opened the throttles and started to taxi at a hot pace across the grass airfield. As we bowled along I was rather self-consciously coping with parachute and seat harness, aids which all but I ignored. By the time I had fastened these we were apparently lined up for take-off, for Santa Cruz tapped me on the shoulder and motioned me to take control. I noticed briefly that the rudder pedals with toe brakes hung seemingly over nothingness where the transparent nose section began. There was a small control wheel and the power levers were mounted on a central pedestal to my left. A shallow instrument panel over to the left containing six blind-flying instruments and principal engine indicators did little to obscure magnificent visibility. Incidentally, all versions of the C.A.S.A. 2.111 have an adjustable rear-view mirror for the pilot.

Without further ado Santa Cruz made an imperious gesture towards the far hedge, indicating that I should take off immediately. I searched quickly for instruments, flap position, compass and obstructions, but the gesture had been so expressive that I dared not delay and began to inch the throttles cautiously forward. I had no idea what to expect. The Heinkel, however, was a real gentleman and what swing to the left there was I held easily by advancing the port throttle a fraction ahead of its companion. The tail came up almost of its own accord and very soon afterwards the aircraft flew itself off. I was worried because I had not yet located the A.S.I. (it was on the other side of the cockpit); and that I had been too optimistic about the initial angle of climb became clear when Santa Cruz pushed the nose firmly down till it pointed almost back at the ground. Speed built up rapidly without any serious trim change and at about 200 km/hr (124 m.p.h.), the rate of climb rose to 5 m/sec (984ft/min) and then to almost 6 m/sec (1,182ft/min). I do not think we used flap for take-off, but the raising of something which I presume to have been the undercarriage caused no more than a series of gentle thumps. The trim wheel is similar in size and form to a car steering wheel and trimming was therefore very easy.

The Spanish C.A.S.A. 2.111, here a trainer with nose gunner/bomb-aimer's position deleted, is virtually identical with the German model and most still have Junkers Jumo engines, though Merlins are now being introduced. "Flight" photographs

By the time we had reached 1,900ft altitude I was the only one not smoking and I settled down to try the stability of the aircraft. This proved to be excellent, with characteristics which gave good control and manœuvrability while maintaining a steadiness most useful for prolonged instrument flying without an autopilot. Trimmed to cruise at 2,200 r.p.m., 1.05 atmospheres boost at 1,900ft, the speed was 290 km/hr (180 m.p.h.) and pulling up the nose and releasing the stick, or pushing it down, resulted in two phugoids, the first very slow and the second of about half the amplitude of the first and a little faster. After that the nose returned to the trimmed attitude and stayed there. Speed varied plus or minus 30 km/hr (19 m.p.h.). Decided yawing with the rudder resulted in several quick oscillations and a positive return to the original heading. With the rudder fixed, the aircraft could be banked to either side and would return to the level attitude when the wheel was released. With the rudder free, on the other hand, the angle of bank remained and a gentle turn started.

Santa Cruz then feathered the starboard engine, leaving the port at cruising power, and made a sharp steep turn to starboard followed by several wing-overs at almost 90 deg bank. The engineer then restarted the starboard and feathered the port engine and the same manœuvres were repeated, not without raising in me a slight home-sickness for terra firma. I took over again, slowed down to 200 km/hr (124 m.p.h.) and found control lighter but no less precise than I should have expected. In all conditions, however, I found that during a turn to the right the nose had to be held firmly above the horizon to avoid losing height, and that the backward stick force required was enough to encourage me to use the trimmer. While Santa Cruz was making steep turns he used the trimmer extensively to apply plenty of g; this appears to be standard practice.

I flew for some minutes at reduced speed, feeling very happy with the aircraft and devoting a good deal of attention to the silver tape of the wandering Guadalquivir river as it wound its way to the sea through the warm sunlight. Then I reduced power and called for flap, which was lowered progressively while we descended in a glide. The nose tended to come up as flap went down, and at 0.6 atmospheres boost and about 190 km/hr (118 m.p.h.) we were descending at 7 m/sec (1,380ft/min). The attitude was not uncomfortably nose-down and the visibility was, of course, excellent. With such an area of glazing in the nose one would practically have to fly backwards before there was any serious deterioration in visibility. The nose cap contain-

The C.A.S.A.-built Heinkel 111 is almost indistinguishable from its German counterpart. The broad-bladed airscrews in these views have been replaced by British units and—as stated overleaf—Merlins are now also progressively replacing the Jumos. Camouflage is pale grey underneath and rather bright red-brown and green on upper surfaces. Roundels are red, yellow and red and the fin carries a black X on white.

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ing the gun-mount is, incidentally, offset to starboard, giving the pilot a clear view through a side panel which is sharply enough inclined to the airstream not to require the ministrations of a windshield wiper. I called for the raising of the flaps and applied power for a simulated overshoot. There was a pronounced nose-up trim change which made me reach quickly for the trim wheel, but there was ample travel available to cope and response was immediate. I climbed to about 1,100 m and spent some time looking directly past my feet at Seville. The inland port on the edge of the city can take quite large ships and there are three airfields quite close by. Tablada was our base, and apart from housing a wing of Heinkel bombers, it served as the test airfield for the C.A.S.A. factory, with which it was connected by a short taxi-track. The aircraft are assembled and wheeled out on to a small grass plot, where they have their first engine runs. Then they are towed to the airfield for test flying. Another grass airfield was until recently used as a Spanish Air Force advanced flying training base. The third field is San Pablo, which has a full complement of runways and is the main civil airport for Seville. It is frequently served by both Iberia and Aviacion y Comercio, using respectively Bristol Freighters and S.N.C.A.S.E. Languedocs. At San Pablo too is the flight test hangar of Hispano Aviacion—a place full of sleek grey Me109s (HA-1112s) carrying eight rocket rails and two 20 mm Hispano cannons apiece. These have now been relegated to the task of advanced flying- and weapon-training in the Spanish Air Force.

By now I had grown quite accustomed to the snarl of the Heinkel's two Jumos as they ran smoothly on either side of the cabin at about the level of my feet. I indicated by signs (the noise level being too high for comfortable speech, especially when I had so few words of Spanish at my command) that I wanted to return and try some circuits and bumps. But Santa Cruz put his own interpretation on this request and pushed the Heinkel into a steep dive. The speed built up till the air hissed loudly round the nose cone and we went into a vertically banked turn with liberal use of the trim wheel. Swooping down over the airfield on the QDM we broke hard on to the downwind leg almost over the landing run. Another steep turn brought us on to "finals" with plenty of height to lose, and wheels were then lowered. We were coming down really steeply towards the landing path when Santa Cruz put the Heinkel into two successive full-blooded level side-slips, with the controls crossed to their full extent. As we came over the hedge he selected flaps and held off as the speed fell off to about 140 km/hr (87 m.p.h.), and touched the main wheels very gently on the grass.

We rolled on across the airfield without any sign of trying to lower the tail or slow down, until I thought that there was not enough room left between us and a stone aqueduct to go round again, nor overmuch room in which to stop. At that point Santa Cruz began to manipulate throttles and brakes to take the Heinkel round in a wide sweeping turn, past lines of parked aircraft and other obstacles, rolling round the airfield with the tail still high in the air. He arrived finally opposite the place where he wanted to park and, raising flaps, turned smartly through 180 deg, put the tail down and cut both engines. We swept up to our place in line with other Heinkels and, as the airscrews stopped turning, drew up smartly with our wing-tip a few feet from that of the next aircraft in line. At that moment the flight engineer said tersely "*todo cortado*" ("everything switched off") and the flight was considered terminated. Santa Cruz said not a word.

I had missed the opportunity to do some circuits and bumps of my own, but had been treated to an exhibition of skill and dash the equal of which I must admit I had not contemplated even in wilder dreams. And that landing was no mad bravado, for Santa Cruz had apparently worked hard to perfect the evolution. He knew the Heinkel inside out, had a great and varied flying experience, mostly test flying, was an acknowledged artist in a Messerschmitt and had flown with a Spanish Me 109 squadron with the Germans in Russia during World War 2. With characteristic Spanish modesty he refused, a little later, to listen to any compliments, but talked willingly and enthusiastically about the Heinkel's excellent flying qualities. But for the moment he sat silently in his seat and let someone else explain to me that he wished me to leave the aircraft first, because he had hurt his leg a few days before while wrestling and needed as much room as possible to extricate himself from his seat.

C.A.S.A. 2.111 (Two Junkers Jumo 211-F engines of 1,340 h.p. each). —Span, 73ft 11in; length, 53ft 6in; wing area, 931 sq ft; aspect ratio, 5.85; maximum weight, 30,800 lb; empty equipped weight, 19,200 lb; maximum load, 11,600 lb; maximum wing loading, 33 lb/sq ft; maximum speed at 19,700ft, 270 m.p.h.; cruising speed at 16,400ft, 223 m.p.h.; service ceiling, 22,000ft; radius of action, according to load, between 675 statute miles and 1,090 statute miles; crew of five.

BRITAIN WINS WORLD MODEL CHAMPIONSHIPS

INTERMITTENT rain during the first two rounds of the contest failed to dampen the spirits of the 57 competitors, representing 16 countries, who took part in the 1956 World Model Power Championships at the College of Aeronautics, Cranfield, on August Bank Holiday. Great Britain gained an even greater success than last year, retaining the Franjo Kluz Trophy—the team award—by a considerable margin, and taking first and second in the individual placings. Winner of the Victor Tatin Cup was Ronald Draper, a 28-year-old architectural assistant from Coventry, on his first appearance in a British Team.

The Power Championships are for models powered by miniature internal-combustion engines with a capacity of up to 2.5 c.c., and built to a strict F.A.I. specification. Each contestant makes five flights during the contest, and tries to gain the greatest possible duration on each flight, the motor run being limited to 15 sec. However, flights of more than three minutes count as three minutes only, so that a perfect score would be five three-minute flights. As at Wiesbaden last year, three competitors (Ronald Draper and David Posner for Great Britain, and Silvio Lanfranchi flying proxy for Lawrence Conover of the United States) had a total of fifteen minutes after five flights, and a "fly-off" (with no limit) was therefore necessary to decide the outright winner. Draper's fly-off time was 5 min 20 sec, with Posner at 4 min 52 sec and Conover at 4 min 15 sec.

In earlier rounds, which began in rain but finished in sunshine, the field had narrowed rapidly. No fewer than twenty-four contestants gained "maximums" in the first round, but only eleven of these repeated the feat in the second round to stay in the running. Michael Gaster (Great Britain), last year's world champion, had a motor over-run of three seconds in Round 2 and, flying again in the brief time before the end of the round, was unlucky to obtain only 1 min 18 sec for this flight. All his other flights were maximums, and he therefore helped Britain to a team victory in which only one flight was less than the maximum possible.

Silvio Lanfranchi, who proxy-flew Conover's model into third place, is a Swiss businessman who lives in Bradford. He actually placed third in the British Trials, but was naturally ineligible for the British team. However, in 1952 he won the contest for Britain, proxy-flying for Barry Wheeler in the United States!

The expected Russian team failed to put in an appearance, claiming commitments "at national contests."

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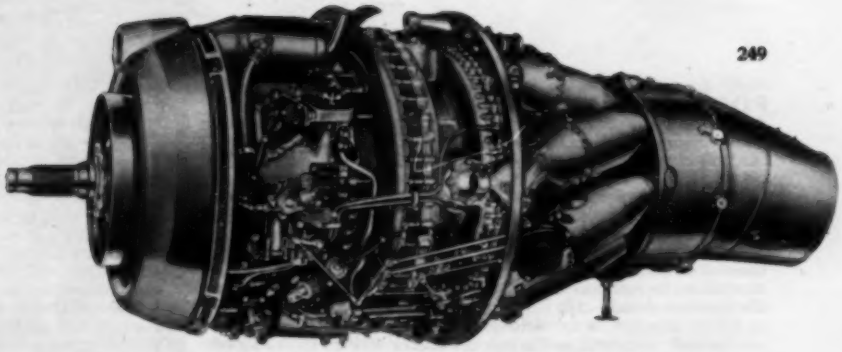

The new Dart 520 (RDa.7) turboprop.

Rolls-Royce Commercial Gas Turbines

By THE TECHNICAL EDITOR

IT has long been appreciated that the supply of any equipment to an airline is a basically different business from that associated with most other branches of aviation. To a high degree the position is akin to that in the longer-established fields of industry and surface transport in that the operator generally shows sales-resistance to "new-fangled" equipment or to the products of a manufacturer who does not already enjoy a considerable background of success among airline customers. This philosophy applies particularly stringently to the supply of airline power-plants. The engine is really the heart of any aircraft and no airliner can be truly attractive unless it is powered by an efficient, long-lived and trouble-free engine. Furthermore, in most cases, an engine starts off at a disadvantage if it is not the product of a company with which the airlines have already established a long and generally happy partnership.

Within these limits there has always been room for several major engine manufacturers to do business. In the past the bulk of the market has been satisfied by America. This still holds true today and more than half of the four-engined equipment at present on order is to be powered by engines made by Pratt and Whitney or Wright. Nevertheless the picture is changing in a remarkable manner. By any standard, the advent of the gas turbine is a factor of the utmost consequence, and it has offered opportunities which British manufacturers have been shrewd and capable enough to grasp. Rolls-Royce in particular have established themselves as the only company in the world who have "got their feet wet" in the commercial gas-turbine business; and it is generally agreed that lasting success in the airline business attends only those who get their feet wet. (The converse, of course, is not necessarily true, neither does it follow that wetting one's feet must involve a protracted fight against a sea of troubles.)

Having soaked themselves up to their knees in the river Dart, the great Derby company have been sufficiently encouraged to spread the whole basis of their civil-engine development. In fact they are increasing the scope of their operations to such an extent that another five years may see them ousting all the great American companies as the source of most of the world's air-transport power. Never before has any company in any country been on the brink of so much business in this highly competitive field. Neither has any company previously been able to offer four quite different families of truly commercial engines matched to the requirements of virtually the whole spectrum of airliner design. In this article it is proposed to recount some of the Rolls-Royce experience and to outline their philosophy.

Dart Turboprop. As is well known, the bulk of the company's experience of commercial turbine operation has been gained with this engine. It has been argued by American engine companies that the value of this experience is reduced by reason of the fact that the Dart is a relatively small engine of early design. Such a contention largely misses the point of the commercial-engine argument, for actual airline experience over a period of years is infinitely more valuable than any amount of military flying. As an example it is possible to cite the famous Merlin piston engine. After World War 2, Rolls-Royce believed that the millions of hours flown by the Merlin in all kinds of military operation would make it a simple matter to develop a commercial derivative. It was soon made painfully clear, however, that, from the airline viewpoint, the Merlin was an almost totally unknown quantity and the company might almost have had to start from scratch. Much the same is true of the Derwent turbojet, for, in spite of its record of more than four million hours as a reliable fighter engine, scarcely any Derwents have been flown in airline fashion and few Derwent components have exceeded 1,500 hr.

The remarkable development of the Dart is shown in Table 1. The history of this engine is unique. There never was a military Dart. The design grew from nothing—unless one includes the supercharger of the last Rolls-Royce piston engines—and grew up with the airlines, with particular emphasis on British European Airways. It is typical of the former chief executive of this corporation that he once referred to the Dart as "agricultural machinery." He said this not with acidity but with affection, for in the airline business the dominant factor is not so much brochure performance as the way in which the engine works. In the Dart, operators have an engine that they can really live with in comfort. Rolls-Royce have already collected quite extraordinary testimonials from over a dozen commercial operators who have described the Dart's behaviour in glowing terms.

Already the operating figures on the Dart are exceptional. The overhaul life of 1,050 hr was first achieved by B.E.A. almost two years ago, when the engine had been on the routes for only 18 months with an operator working at the low utilization of five hours per day. Operators can now reach the 1,050-hr mark in a much shorter time; last October Hunting-Clan reached this figure after four months.

Outside North America the Dart is generally established at 1,050 hr. Throughout 1955, flame tubes were normally changed at 500 to 600 hr, but today a revised design of flame tube (referred to below) is employed, with the same 1,050-hr life as the remainder of the engine. In North America competitive airline operations tend to demand higher powers at lower altitudes, imposing rigorous operating conditions with high flame-temperatures and mechanical loadings. Past operations by T.C.A. and Capital have been on a 1,400-hr basis with a change of the first-stage compressor impeller at 700 hr.

Next year the Dart will certainly be placed on a basis of 1,500 or 1,600 hr with no parts-change whatever, except for the various filter elements. This type of performance fully matches the best which can be achieved with reciprocating engines. In the gas turbine, however, quite a different kind of cost-structure prevails. Each piece of the engine has a particular authorized life and cost, and something like 80 per cent of the operating cost on the Dart is in pieces lifed at more than 2,000 hr. It is, therefore, impossible to determine a completely representative cost-per-hour figure until the carcase-life of individual engines has reached at least 3,500 hr.

Turning to the mechanical features of the engine itself, the basic Dart 505-506 has already been fully described in past issues, that of January 14, 1955, being particularly informative. Virtually all the 505s have now been converted to 506 standard during normal airline operation. Relatively recent modifications to the 506 include a new design of first-stage impeller and a flame tube incorporating skin cooling along lines suggested by Dr. J. S. Clarke of Joseph Lucas (G.T.E.), Ltd. As an indication of the beneficial effect of skin cooling, seven such tubes (a complete set for one engine) were recently returned for a further 500 hr after inspection at 1,230 hr. Thus flame tubes, which last year were removed after 500 or 600 hr, are already cleared for one full engine life and are considered to be good for double this life without attention. Dart 505s and 506s were fitted to 124 Viscounts which have gone "out of the door" at Vickers and it is on these that most of the airline experience has been built up.

Most Darts at present in production are of the series 510, in which an increased-capacity helical reduction gear provides for greater take-off horsepower, and other modifications improve the power and specific fuel consumption under all conditions of operation. It is pertinent to emphasize that certain short-haul operators are particularly glad to receive the 510 owing to the increased climb performance which it offers. The restriction imposed by the Dart 506 reduction gear on low-altitude shaft horsepower has been of little consequence in Europe, where the airline accent is on economy; in America keen competition has led to sustained Viscount operations at high power and at relatively low cruising altitude and here the 510 has proved invaluable.

Into the 510 has been built all the experience gained with the

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earlier engines, and there is no reason to doubt that the overhaul life will rapidly become equal to that of the less-powerful 506. So far 151 Viscounts have been ordered with the 510, representing a total, with spares, of 782 engines. Flight time on the Dart 510 is scheduled to exceed 1,500,000 hr by the end of next year. The standard engine for the production Fokker Friendship is the Dart 511, generally similar to the 510 except for a reduction gear ratio of 0.086:1, better suited to the larger airscrew. Including aircraft to be made in the U.S.A. by Fairchild, Friendship production has already called for over 100 Darts from Derby.

All the engines so far delivered (of series 505, 506 and 510) are basically identical, and in practice several airlines have carried out conversion from series 505 to 506 during major overhauls. All three are now highly reliable units and provide a firm basis for the later types of Dart which are substantially redesigned and are not convertible from the earlier engines.

First of the new Darts is the series 520 engine at RDa.7 rating. In this unit a completely new design of turbine with three stages is employed to give the additional shaft power required to drive an increased-capacity compressor and still leave enough surplus to take the airscrew power into the 2,000 h.p. bracket. Further improvements include detail design changes, such as revized combustion equipment and a slightly strengthened reduction gear (the oil cooler is now to be a single unit, and not a double-barrel design as we stated in our issue of May 11). The heading (p. 249) illustration shows the appearance of the new Dart 520.

Production 520s are due to become available next April, the first application being the Viscount V.806 of B.E.A. Following what Rolls-Royce expect to become standard practice, the engine will be operated at a restricted power of 13,400 r.p.m. for about one year, after which it will be cleared for full cruising power at 14,000 r.p.m., with reduced specific fuel consumption notwithstanding the corresponding increase in turbine-inlet temperature. A basically identical unit is the RDa.7/1, which incorporates a minor modification to the fuel system to allow all the power inherent in the machine to be realized. The RDa.7/1 (or Mk 525) is due for delivery in September 1957.

One factor which the accompanying tables emphasize is the difference in engine requirements between the Viscount and the Friendship. The former is power-limited to 1,800 s.h.p. and, although later Viscounts are stronger and have more powerful control characteristics to meet the requirements of operation at higher indicated airspeeds and weights, the full power of the later Darts will not be used. An incidental advantage of this is that it will ease the altitude/temperature limits during which maximum power will be available for take-off and climb. In contrast, the Friendship engine is designed to provide the maximum possible shaft power so that the ratings of the later Darts differ markedly according to their application, even though the engines themselves are basically identical. Thus the Friendship counterpart of the RDa.7/1 will be designated RDa.7/2 and will have the same reduction gear ratio as the Dart 511. At present orders for the 520 series total 208, all for various 800-series Viscounts.

Some way behind the 520 will come the production engine at the advanced RDa.10 (previously RDa.8) rating of over 2,500 e.h.p. In these units the basic design of the Dart will be stretched and refined to give an engine which will not only match its axial contemporaries in most aspects of performance, but will have a background of experience and know-how unapproached by any other turboprop.

To evolve the RDa.10, Rolls-Royce have borrowed the back-end techniques of the later military turbojets in having cooled turbine blades to allow operation at considerably increased turbine-inlet temperature. Compared with engines of RDa.7 rating, the RDa.10 will have an improved compressor, a strengthened reduction gear and an increased-capacity turbine with air-cooled high-pressure turbine blades of improved material. Certain parts of the carcase will be identical with those of the RDa.7, but it is not envisaged that the engines will be mutually convertible. Production RDa.10s are to be made available from January 1959 and all aspects of their performance have already been proved in extensive rig running. Approximately two years later a still further developed engine will become available incorporating improved cooling in the high-pressure nozzle guide vanes and turbine rotor blades to allow an additional increase in top temperature (which in the turboprop produces an all-round improvement in performance). The developed RDa.10 will also incorporate a slightly modified fuel system.

With these much more powerful engines the respective airframe limits of the Viscount and Friendship will cause their respective families of powerplants to diverge in shaft-power still more widely. Whereas in the Dutch airframe the maximum power will rise to more than 3,000 e.h.p., the fuel flow of the Viscount engine will be restricted under i.s.a. conditions at sea level in order to limit the top temperature and hence cut down the power. The accompanying tables state the manner in which this power limitation will allow the i.s.a. power at low altitudes to be maintained up to quite high temperatures.

These tables outline the altitude/temperature limits of all the latest Darts. It is apparent that the Dart 520 family will, with water/methanol injection, be able to maintain i.s.a. take-off power appropriate to airfield altitude up to i.s.a. +30 deg C. Alternatively, the injection system can be set to maintain sea-level rated power up to i.s.a. +30 deg C at low altitudes, and at lower ambient temperatures to rather higher altitudes. Dart RDa.10s for Viscounts will, owing to their power limitation at sea level, usually be able to dispense with water/methanol and will be capable of putting out full sea-level power to an appreciable altitude under i.s.a. conditions (or, at sea level, to high ambient temperatures). In all cases, the use of water/methanol will have no effect on high-altitude cruise operation.

As already noted, the Friendship engine will be able to use all the shaft horsepower that can be provided, and in this aircraft the RDa.10 rating will eventually enter the 3,000-h.p. class. Earlier Darts have been tailored to the cruise requirements of the Viscount, and in this relatively fast aircraft a small-diameter jet pipe has been used to give high propulsive thrust at the expense of some shaft horsepower. In the slower Friendship a larger tailpipe will be employed terminating in a 17in nozzle, 2in larger in diameter than that currently employed. By this means a higher proportion of the power is put into the airscrew to give outstanding field performance, the small penalty in jet thrust being a factor of minor importance to the Friendship, particularly as the jet leaves at about 34 deg to the line of flight. The schedule for Friendship engines is generally about a year behind that for equivalent Viscount units; the RDa7/2 is due for delivery early in 1958, the RDa.10 for early 1960 and the developed RDa.10 for early 1962.

It should be quite clear from the foregoing that the Dart is a quite outstanding unit and it may well achieve additional success in the re-engining of several types of existing piston-engined transports. Rolls-Royce are committed to build some 1,840 Darts to meet the requirements of Viscount and Friendship orders already signed. By the end of 1959 over ten million hours will have been flown on present programmes (the current in-service figure is approximately 1,250,000) and by 1961 the whole Derby factory could be occupied entirely on the manufacture of Dart spares (again on the basis of existing orders).

Tyne Turboprop. It was as long ago as World War 2 that Rolls-Royce designed a turboprop of 4,000 h.p. This engine, the R.B.39 Clyde, was an excellent and reliable unit and it seems a great pity that lack of support forced its abandonment in 1949. Compared with the Clyde, the R.B.109 Tyne is as different as is chalk from cheese. A lot of water went under the bridge between the two designs and the Tyne is perhaps the first turboprop in the world to have been designed by engineers who knew from experience how to evolve the optimum commercial engine. There is every reason to believe that the Tyne will not only equal the Dart in reliability, but will set a new high standard of efficiency and economy.

Airworthiness hazards with turbine engines can assume awe-inspiring proportions. With the familiar piston engine hazards are well understood and operators can face any kind of failure with equanimity. In fact catastrophic failure in reciprocating powerplants is almost impossible, excepting the loss of an airscrew blade. With the gas turbine the operator faces intrinsically greater hazards involving types of failure which can be destruc-

Table 1: Performance of Later Darts in Viscounts

Take-off, s.l., i.s.a. (dry), 15,000 r.p.m.: RDa. 7 (1957), 1,890 e.h.p. (1,700 b.h.p.) maintained dry up to i.s.a. + 12 deg C at s.l.; RDa. 7/1 (1958), 1,990 e.h.p. (1,800 b.h.p.) maintained dry up to i.s.a. + 6 deg C at s.l.; RDa. 10 (1959), 2,080 e.h.p. (1,800 b.h.p.) maintained dry up to i.s.a. + 27 deg C at s.l., 12,000ft at i.s.a.; developed RDa. 10 (1961), 2,080 e.h.p. (1,800 b.h.p.) maintained dry up to i.s.a. + 38 deg C at s.l., 17,000ft at i.s.a. Unrestricted, the RDa. 10 will give 2,395 s.h.p. plus 675 lb thrust.

Maximum continuous, s.l., i.s.a.: RDa. 7, 1,720 e.h.p. (1,555 b.h.p.) at 0.71 lb/hr/e.h.p., maintained up to i.s.a. + 12 deg C at s.l.; RDa. 7/1, 1,820 e.h.p. (1,620 b.h.p.) at 0.695 lb/hr/e.h.p., maintained up to i.s.a. + 6 deg C at s.l.; RDa. 10, 1,955 e.h.p. (1,740 b.h.p.) at 0.71 lb/hr/e.h.p., maintained up to i.s.a. + 19 deg C at s.l., 9,000ft at i.s.a.; developed RDa. 10, 1,955 e.h.p. (1,740 b.h.p.) at 0.72 lb/hr/e.h.p., maintained up to i.s.a. + 28 deg C at s.l., 13,500ft at i.s.a.

Maximum recommended cruise, 20,000ft, i.s.a. 350 knots: RDa. 7, 1,145 e.h.p. (1,075 b.h.p.) at 0.60 lb/hr/e.h.p., 13,400 r.p.m.; RDa. 7/1, 1,360 e.h.p. (1,285 b.h.p.) at 0.565 lb/hr/e.h.p., 14,000 r.p.m.; RDa. 10, 1,710 e.h.p. (1,535 b.h.p.) at 0.540 lb/hr/e.h.p., 14,200 r.p.m.; developed RDa. 10, 1,840 e.h.p. (1,635 b.h.p.) at 0.53 lb/hr/e.h.p., 14,300 r.p.m.

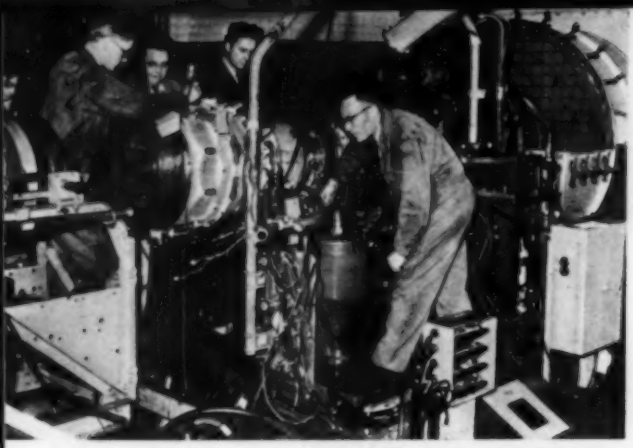
Table 2: Later Darts in Friendship Aircraft

Performance with 17in diameter exhaust outlet

Take-off (s.l. static, i.s.a.) dry, 15,000 r.p.m. maintained up to i.s.a. + 30 deg C by water/methanol injection, RDa. 7/2 (1958), 2,145 e.h.p. (2,020 b.h.p.); RDa. 10 (1960), 2,745 e.h.p. (2,570 b.h.p.); developed RDa. 10 (1962), 3,150 e.h.p. (2,970 b.h.p.).

Maximum continuous, s.l., i.s.a.: RDa. 7/2, 1,945 e.h.p. (1,830 b.h.p.) at 0.670 lb/hr/e.h.p.; RDa. 10, 2,385 e.h.p. (2,235 b.h.p.) at 0.645 lb/hr/e.h.p.; developed RDa. 10, 2,625 e.h.p. (2,470 b.h.p.) at 0.635 lb/hr/e.h.p.

Maximum recommended cruise, 20,000ft, i.s.a., 250 knots: RDa. 7/2, 1,300 e.h.p. (1,285 b.h.p.) at 0.570 lb/hr/e.h.p.; RDa. 10, 1,560 e.h.p. (1,505 b.h.p.) at 0.565 lb/hr/e.h.p.; developed RDa. 10, 1,680 e.h.p. (1,615 b.h.p.) at 0.560 lb/hr/e.h.p.



A development Tyne being prepared for bench-running at Sinfin, near Derby. The first thousand hours have been extremely encouraging.

tive. During Dart development, and in their military work, Rolls-Royce have probably learned more than any other company in the world how to make a gas turbine a safe prime mover for commercial airline operation. In the Tyne, designers have been working from the ground up on a concept specifically aimed at such operation, and the resulting engine should already be one of the safest gas turbines yet developed.

One of the most catastrophic failures is that resulting from bursting of a turbine disc. Equally disastrous results can occur as a by-product of any of several dangerous overspeed conditions. As a result of the first Dart decade Rolls-Royce have evolved a comprehensive procedure for investigating the mechanical properties of new gas turbines. Every conceivable mechanical failure likely to occur in practice is actually induced during bench running, and subsequent behaviour then studied in detail.

During the past few years the company have been consistently and deliberately demonstrating such failures. For example, a Dart can be run with a weakened main rotor shaft, which is then broken under overspeed conditions. In the Tyne the whole problem is considerably more complex owing to the greater mechanical complication of the engine. An accompanying diagram outlines some of the types of failure which have already been investigated.

Rupture of turbine discs has already been investigated in great detail. The old austenitic discs were always known to be prone to failure, and it is agreed that every such disc will fail sooner or later although the early military engines rarely logged enough time to get into dangerous hours-per-engine regimes. Largely as a result of the early experience with the Avon (*Flight*, December 16, 1955), a new form of turbine construction has been evolved embodying pressure-cooled ferritic discs carrying extended-root blades with complex quality control applied at every stage. With such turbines it is possible to show a definite safe life for the complete unit under varying conditions of damage—such as a large crack of a type which would obviously be found on inspection. To demonstrate this, a disc is clamped in the laboratory and resonated electro-magnetically until a crack capable of being seen without etching becomes visible—which may not be until months later. The disc is then built into an engine and cycled on the bench to demonstrate that the crack fails to propagate. With present Rolls-Royce commercial engines it is considered permissible to maintain services with a cracked turbine disc, knowing that the fault will be picked up at the next inspection.

Already it has been learned from repeated evidence that, should a secondary failure cause an already cracked disc to overspeed, the turbine will shed its blades (thus killing the speed) at r.p.m. safely below the bursting limit. This is a unique position which it is firmly intended shall be maintained on later engines. One must, of course, accept that any component subjected to vibratory stress will eventually suffer from fatigue, but Rolls-Royce do not believe that any such component need be hazardous. Blade characteristics, for example, can be so chosen as to pull down the vibratory stresses out of the full-power range, and it can then be ensured that if a blade should fail it will do so either on the ground before take-off or at conditions of low r.p.m. On centrifugal engines it is possible to develop an impeller in which a fatigue crack propagates outwards and never runs to the root. On axial engines the company's philosophy is that no blade should ever go through the carcase or even let any gas out—a fact which is demonstrated for each new engine type and which has already been proven for the Tyne.

In Rolls-Royce commercial engines the early stages of compressor blading are of light alloy. Following failure, such blades are certain to be contained inside the engine without an excessive weight penalty in the casing. It is Derby policy to pin-fix compressor blades, a practice which would not be possible with large early-stage blades made of steel. Such a fixture removes the basic flexure and allows the blade to yield under heavy impact, such as might occur during icing conditions. Furthermore it is possible to play with the pin clearances until the blade-frequency is tuned out of the engine running range. Perhaps surprisingly, another reason for preferring light-alloy blades is the behaviour of the blade after foreign-body impact. In a steel blade such impact may cause only a small leading edge "nick" which is not readily visible except under a glass in the shop. Unless, through an extreme stroke of luck, the impact happened to occur at an anti-nodal point, it is likely that such a nick would form an origin for a crack. Were a steel-bladed engine to pick up a stone during take-off from New York it could quite conceivably cross the Atlantic, pass an inspection and then suffer complete blade failure on the return trip.

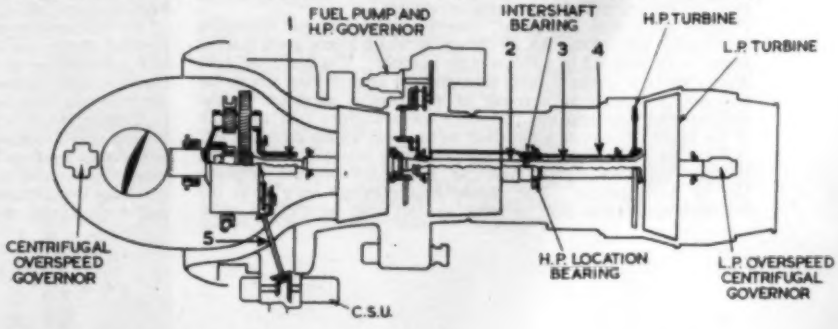
Roughly one million hours with aluminium-blade engines in Canberras has already sufficed to show the tremendous advantage of the softer material. Impact with a foreign body causes a relatively large gash, invariably with a fair radius at the root. For this reason the deformation is much less of a stress-raiser and it may take over 100 hr before a crack develops. During all this time it is possible to see any crack which could lead to trouble merely by looking down the intake with a torch. Such a simple procedure as *in situ* visual inspection has been adequate to keep failures down to one Avon every 10,000 hr during normal military flying—and, so far, there has not been one blade failure with a damage mark as an origin.

Actually the Tyne compressor makes extensive use of titanium, largely owing to the considerable temperature rise caused by the high design pressure ratio of 13:1. Both the large front low-pressure spool and the slim rear high-pressure spool of the Tyne compressor are virtually direct scales of the corresponding units in the Conway. Naturally, as all the flow through the Tyne low-pressure compressor also passes through the high-pressure assembly (there being no by-pass flow) the scales are different for the two spools, i.e. the Tyne high-pressure section is relatively larger. The whole design of the compressor is exceedingly advanced and, as well as having the highest pressure ratio yet announced for any engine in the world, it handles more than twice the mass flow of the Dart in a diameter of barely 20in. Other features of the Tyne include a quiet-running, self-centring, two-stage reduction gear surrounded by the intake and an integral annular oil tank; a can-annular combustion system with very high efficiency and special provision for easy maintenance; and an advanced back-end design incorporating high-pressure air-cooling in the nozzle guide vanes and rotor blades of the single high-pressure turbine stage.

When the design of the Tyne was finished Rolls-Royce knew that they were in a position to make it financially as attractive as any commercial powerplant in the world. Its history provides an example of the way in which the company believe an airline engine should be developed.

The first prototype ran in April 1955, by which time rig testing had largely proved the basic rightness of every part of the design. Exactly a year later a full 150-hr test was run to type-test schedule at the design flame temperature. Nevertheless the engine will not be officially put up for type-testing until some six months ahead of production, since it is company policy to leave such testing until the last possible moment. Bench testing against water dynamometers has now sufficed to complete most of the basic development of the engine as a unit and hangar testing with both de Havilland and Rotol airscrews is doing the same for complete powerplants. The latter work is principally concerned with the Tyne 506 installation for the Vickers-Armstrongs V.951 Vanguard.

A single Vanguard-type installation was made in the nose of an Avro Lincoln test bed earlier this year and flight trials with this aircraft began at the end of June. The total present running



***Possible failures examined during bench development of the Tyne. They are:** 1, shear of drive between reduction gear and l-p. compressor; 2, failure of drive to l-p. compressor forward of intershaft bearing; 3, as for 2 but rearward of the intershaft bearing; 4, fracture of drive from h-p. turbine to h-p. compressor; and 5, failure of drive to c.s.u. All these have been made "safe" as a result of such investigation during take-off and descent conditions.*

FOUR DERBY WINNERS . . .

time amounts to over 40 hr in the air and more than 1,000 on the bench. Next summer Rolls-Royce will install two Tynes in an Elizabethan borrowed from B.E.A. for endurance flying. In view of the success of the Dart-Dakota used on scheduled B.E.A. freight services, it is probable that similar operations will be carried out with the Tyne-Elizabethan. The official type test is scheduled for September-October 1957 and the prototype Vanguard is due to fly in September 1958. The Lockheed Aircraft Corporation are also considering the purchase of Tyne engines for evaluation as an alternative powerplant for the Electra. This type of Tyne is due to be type-tested in November 1958 and certificated engines ready for Lockheed early in 1959.

Vanguard-engine development is outlined in an accompanying table. Recently a minor redesign was incorporated in the compressor to give powers which exceed those so far published and render all the tabulated figures pessimistic. Within limits it should be possible to select any low-pressure cruise r.p.m. to give the required balance of fuel consumption, airspeed and noise level. In B.E.A. service it is probable that the latter factor will be predominant and it is unlikely that the low-pressure setting will exceed 12,500 r.p.m.; in North America no doubt Tyne-powered aircraft would be cruised as fast as the requirements of economic overhaul life would allow. On the Vanguard the reduction gear ratio is 0.064, the airscrew being a de Havilland four-blade unit of 14ft 6in diameter.

Operations with British European Airways are due to start early in 1960, by which time engine flight-hours on the Tyne-Elizabethan, supported by the first V.951s, should be about 10,000. It is expected that initial certification by both the A.R.B. and C.A.A. will be on a basis of 400 or 500 hr. The Tyne 506 "Stage 1" engine should reach the fully-fledged, 1,000-hr basis by the middle of 1961. At this time the "Stage 2" engine is due to be introduced to service, with a higher top temperature as a result of improved turbine-disc cooling and a new blade material. Two years later the "Stage 3" Tyne is scheduled to go on to the routes. This engine is at present the ultimate version for which a firm programme is being quoted; like the later Darts it will feature improved blade cooling in the high-pressure turbine stage.

Table 3: Performance of Tyne engines in Vanguard aircraft

Engine data: Diameter, 40.5in; length, 100.25in; weight, 2,023 lb; pressure ratio, 13 : 1.

Take-off, s.l. static, i.s.a., 15,250 r.p.m.: Stage I (1959), 4,695 e.h.p. (4,220 h.h.p.); Stage II (1961), better than 5,075 e.h.p.; Stage III (1963), better than 5,500 e.h.p.

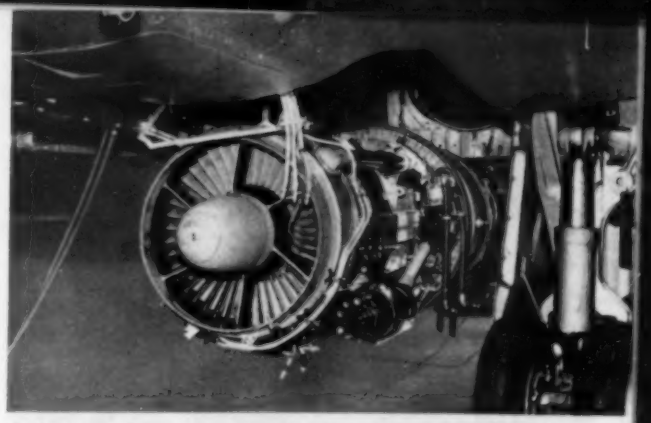
Maximum recommended cruise, 25,000ft, 370 knots, all figures (power and s.f.c.) will be from three to five per cent better than: Stage I, 2,700 e.h.p. at 14,000 r.p.m. at 0.412 lb/hr/e.h.p.; 2,640 e.h.p. at 13,500 r.p.m. at 0.411 lb/hr/e.h.p.; 2,550 e.h.p. at 13,000 r.p.m. at 0.413 lb/hr/e.h.p.; Stage II, 2,990, 2,920 and 2,820 e.h.p. at same r.p.m. with specifics of 0.398, 0.398 and 0.400; Stage III, 3,090, 3,030 and 2,940 e.h.p. at same r.p.m. with specifics of 0.399, 0.398 and 0.398.

Avon Turbojet. As a military engine the Avon is as experienced as any unit in the world. It has now been widely employed for six years in bombers, fighters, trainers and transports and enjoys an enviable reputation for reliability. The first family of Avons is based on the Series-100 engine, with a 12-stage compressor, eight separate combustion chambers and a two-stage turbine. These engines were fully described and illustrated in our issue of December 16, 1955. The much more advanced 200-series Avon may not yet be described in detail.

Development of commercial Avons began in 1950 when the de Havilland Aircraft Company decided that, in view of the weight growth of the Comet, it would be desirable to turn to an engine basically more powerful and efficient than the centrifugal Ghost. Rolls-Royce accordingly prepared variants of the Avon 100 family designated Avon 500-503, and these were used in the Comet 2 at ratings of between 7,150 and 7,350 lb. This work served to sort out most of the basic airline maintenance problems associated with such an engine. Present R.A.F. Comet C.2s and T.2s have a military counterpart of these engines designated Avon 117-118. As an indication of their quality, it is now over two years since Canberra engines (which are generally similar) were first run to an achieved life of 800 hr between overhauls. During many hundreds of thousands of hours of Canberra flying it has been shown that the incidence of unscheduled engine-changes is below 0.3 per 1,000 hr flying, even on rugged military training schedules.

From the airline viewpoint, interest centres on the 200-series commercial unit of the RA.29 rating, in which every good quality seems to be blended in a remarkable manner The latest military Avons are now giving thrusts substantially greater than any so far announced, largely as a result of progressive increases in the turbine-inlet temperature. It is on these engines that the bulk of the 6,000+ hours on air-cooled turbine blades has been gained.

Running at such fearsome temperatures inevitably raises the specific fuel consumption and the RA.29 follows the opposite line of development. The thrust requirements vary with the airframe application but, in most aircraft with which it is associated, the RA.29 can easily meet all requirements at almost unbelievably low turbine-inlet temperatures. A further factor is that maximum thrust (10,500 lb dry at 8,000 r.p.m.) is required only while the wheels are on the ground during take-off; during all the rest of each flight—in the Comet 4 at least—the cruising r.p.m. of 7,150 represents an unusually low proportion of the maximum thrust.



A five-figure-thrust Avon being withdrawn from the de Havilland Comet 3; the production RA.29 will appear somewhat different.

Details of the RA.29 are withheld but it can be stated to incorporate a revised design of compressor extended at the front to increase the mass flow and pressure ratio and requiring a third stage to be added to the turbine. The engine is a straightforward derivative of the latest military units according to the philosophy of operation at exceedingly low gas temperature. For this reason there is no doubt that it should be quite possible to achieve remarkable component lives and the expected overhaul life on the complete powerplant should fairly rapidly approach 2,000 hr.

A few weeks ago a complete type-test schedule was run on an RA.29 with performance almost identical with that predicted. The first public appearance of the engine is expected to be at this year's S.B.A.C. Show, when one will be flown in a special Canberra test bed. Similar units are also to be installed in the outboard positions on a pair of Comet 2s; redesignated Comet 2E these aircraft will be used by B.O.A.C. for route proving, endurance and general development. The programme is intended to establish, in terms of demonstrated performance, a minimum A.R.B.-approved life of 500 hr by mid-1959 and the company are certain that the RA.29 will then already be a 1,000-hr engine subject to demonstration of ability. B.O.A.C. and Capital Airlines are scheduled to put the Comet 4 on to the routes in the winter of 1958-1959, by which time the RA.29 should have logged over 10,000 hr flying and military Avons more than 3,000,000 hr.

Present orders for Comets require the delivery of approximately 200 Avons, to which can be added more than 30 for Air France Caravelles. In the present state of the market it is unwise to suggest how these numbers might increase in the coming months. Rolls-Royce are also in an excellent position for supplying commercial Avons as a ready and available turbojet for such aircraft as the Douglas Model 1925 (DC-9). During the next six months it is quite likely that the whole medium-range jet market may break wide open and, if the RA.29's leading position is confirmed by selection for American airframes, the volume of business that could result is tremendous by any standard. Naturally enough Rolls-Royce are not anxious to give details of what form of engine they have in mind for the DC-9, but it can be said that investigations are proceeding upon lightened versions of the RA.29 for such applications. This is quite practicable owing to the low ratings required and the easy, cool operating conditions.

A firm Rolls-Royce philosophy employed in the RA.29 is that all cabin pressure air is tapped directly from the main engine compressor. This practice has been amply justified by past experience and the unlikelihood of contamination by synthetic oil is shown by the almost insignificant oil consumption of about 0.07 pints per hour per engine (the Viscount V.700, incidentally, used a total of a quart of oil during its entire flying time on the New Zealand race three years ago). The lubrication system is an integral part of the Avon. The inbuilt capacity is 15 pints and the oil cooler is fuel-cooled (requiring no intake and thus giving rise to no drag). Standard equipment includes electric starting, high-energy ignition, automatic synchronization and a power take-off for an accessory gear box. Although they have kept quiet about it, Rolls-Royce are also in a leading position in the development of thrust-reverse units for commercial and military aircraft. These, together with various forms of quiet-running (Greatrex) nozzle, are being actively developed. In the latter work the company are exchanging ideas with several airframe manufacturers, including Boeing and Douglas.

Conway By-Pass Engine. It is remarkable that, at the present time, the Conway is the only example of a type of engine which has long been known and which offers a most interesting compromise between the conflicting factors which make for propul-

sive efficiency in a jet-type engine. The basic thinking behind the by-pass turbojet is quite straightforward. If one assumes that the component efficiency is 100 per cent throughout, then the power developed in any jet-type engine depends on the pressure ratio, the top temperature and the mass flow. The cycle efficiency, i.e., specific fuel consumption, depends only on the pressure ratio. In practice, of course, the component efficiencies are something less than 100 per cent and, when this is taken into consideration, the cycle efficiency is found also to be a function of top temperature.

For shaft-driving engines it is therefore advantageous, from both the specific-power and efficiency points of view, to increase the combustion temperature to the practicable limit. Where the thrust is derived from a propulsive jet, however, one must also consider the propulsive, or Froude, efficiency, which is a function of the difference between the speed of the jet and the speed of the aircraft, both measured with respect to still air. As combustion temperature is increased the jet velocity also rises and the propulsive efficiency falls. Eventually an optimum temperature is reached above which, although the thrust will continue to rise, the specific fuel consumption will begin to worsen.

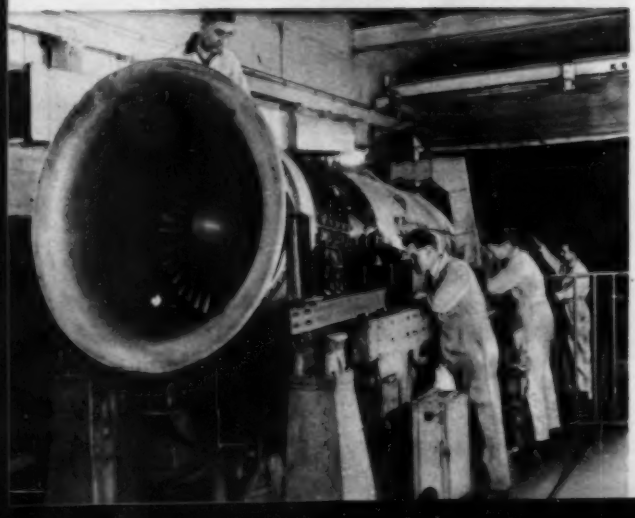
During the past few years progressive improvements in hot-end construction, and in particular the use of air-cooled turbine blading, have allowed increases in combustion temperature to a point at which specific fuel consumption is being seriously affected. In the supersonic aeroplane this is of secondary importance, but in the high-subsonic bomber or transport it is desirable to suppress the maximum temperature. In fact, for a turbojet with a high pressure-ratio cruising at 550 m.p.h. at 40,000ft, the combustion temperature for the best specific fuel consumption is only about 600 deg C, which is very much less than the values at which the latest military engines are now operating.

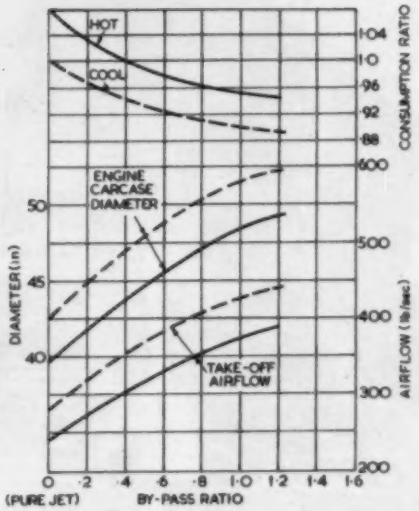
In the by-pass engine the blades of the forward (low-pressure) compressor are made very long so that they can handle a tremendous mass flow. Part of this flow is ducted around the remainder of the engine and expelled as a relatively cool propulsive jet of atmospheric air. The air from the inner portions of the low-pressure compressor is taken through the second (high-pressure) compressor, through the combustion chamber and turbine section and finally emerges as a fast-moving hot core surrounded by the by-pass jet. The jet velocity is no more than moderate, the outer by-pass jet being inherently slow-moving and the inner hot jet being partly de-energized by the energy extracted through the turbines to drive the by-pass flow. On the debit side is the increased size of low-pressure compressor (compared with an equivalent simple turbojet) and the fact that there must be losses in the transfer of energy from the hot gas to the ducted air.

By-pass investigation has been going on at Derby for some eight years. With a development contract from the Ministry of Supply, design progressed on various engines named Conway and the first of these ran in August 1952 at the RCo.2 rating of 9,500 lb thrust. This was equal to the rating of what was then the latest member of the corresponding family of pure turbojets, the RA.14 series of Avon.

One of the chief factors to be settled in the design of an engine like the Conway is the by-pass ratio, i.e., the mass flow in the by-pass flow expressed as a proportion of that going through the high-pressure section of the engine. During the development of the Conway this factor has by no means remained constant, and much of the future development of the engine will be devoted to increasing the ratio from the present average of 0.4–0.5 to something like 0.8. This has been made possible largely by the "podded" installation used in the American jet airliners—which the managing director of Vickers-Armstrongs (Aircraft) recently referred to as "God's gift to the by-pass engine." Design investigations show that this will not raise the engine weight although specific fuel consumption steadily improves as the by-pass ratio is increased. The gain expected is of the order of an additional

One of the earlier types of Conway by-pass turbojet about to start bench-running. Note the great length of upstream blading.





By-pass characteristics: curves showing the effect of variation in by-pass ratio on a unit rated at 20,000 lb thrust. The full lines represent a hot engine weighing 5,000 lb and the broken lines a cooler-running unit weighing 5,800 lb. The consumption ratio is the fuel consumption at 475 knots (stratosphere) expressed as a ratio of that of a simple cool-running turbojet.

six per cent, which Rolls-Royce calculate is equivalent to a range improvement of rather more than ten per cent compared with a simple turbojet.

Development to the RCo.3 rating in July 1953 produced a substantial increase in thrust to a value of 11,250 lb. An engine of this type was successfully put through a simulated 150-hr type-test in July 1954. Full type-test approval was gained in July 1955 by the RCo.5 which incorporated detail changes. The type-tested thrust was 13,000 lb, and it was then announced that the recorded specific fuel consumption was lower than that for any other type-tested jet engine. Last year the RCo.5 was mounted in an external pod beneath the fuselage of an Avro Ashton test bed converted by D. Napier and Son at Luton. With this aircraft full investigation of flight performance has already been made.

The first order for the Conway was announced on May 9 of this year, when Trans-Canada Airlines publicized their purchase of four Douglas DC-8 Model 1910 long-range transports, with an option on two more. Delivery to the airline was to begin in December 1959. This order marked the first major change in a buying pattern which had been established for 200 aircraft for similar applications. Explaining their departure from accepted practice, T.C.A. commented not only on their happy past association with Rolls-Royce, but also on the fact that, compared with its American counterpart, the Conway promised to be appreciably lighter, cheaper and more efficient.

Aircraft of the calibre of the "inter-continental" DC-8 and Boeing 707 need engines with greater thrust than any yet announced for the Conway or any other commercial engine. Estimates of the actual thrust required have been made in the bracket 15,000-17,000 lb, and to meet this ambitious target Rolls-Royce are currently producing a new family of exceedingly advanced Conways capable of delivering approximately twice the thrust of the first engine. In order to establish an economic programme and also as a means of improving the striking power of Bomber Command, the Ministry of Supply are to purchase a considerable number of production engines of this new high-thrust family for installation in one or more types of V-bomber. Rolls-Royce already have a firm commitment to produce such an engine in numbers.

The civil "advanced Conway" is the RCo.10 and it promises to be the most efficient powerplant for long-range jet transport yet developed. Flight development with the Ashton has permitted existing Conways to be demonstrated at the altitude, thrust and specific fuel consumption which have been guaranteed for the RCo.10, although of course the present engine has to run at higher r.p.m. owing to its smaller diameter. Compared with the future military powerplant, the RCo.10 will be somewhat derated by running at lower gas temperatures. As a result, no special development problems are foreseen. Military orders will provide a substantial background of flying during the 40 months available before delivery to T.C.A. It is expected that full A.R.B. and C.A.A. clearance will be granted within three years and that the RCo.10 will be put on a 1,000-hr basis within 18 months of first service. The latter should be easier to achieve than it has been with short-range engines, owing to the fact that the utilization of the DC-8s should be of the order of 11 to 13 hr per day.

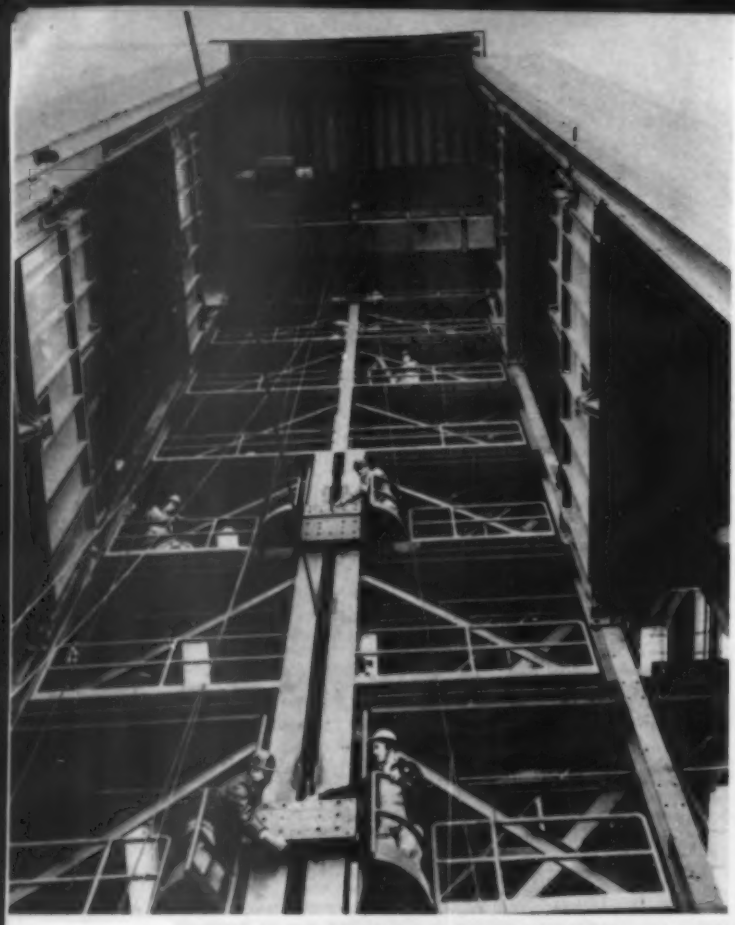
Features of the DC-8 installation are electric starting, a fuel/oil heat exchanger, reverse thrust and a silent-running nozzle. For Boeing, Rolls-Royce have undertaken to supply complete power nacelles incorporating the reverse-thrust unit and silencing nozzle. These nacelles would be shipped to Seattle, and Rohr Aircraft of Chula Vista, California, would supply installation components and the pylon strut. Rolls-Royce are confident that other operators will follow the example of T.C.A. in specifying the Conway for future orders of long-range jet transports.

NAVAHO

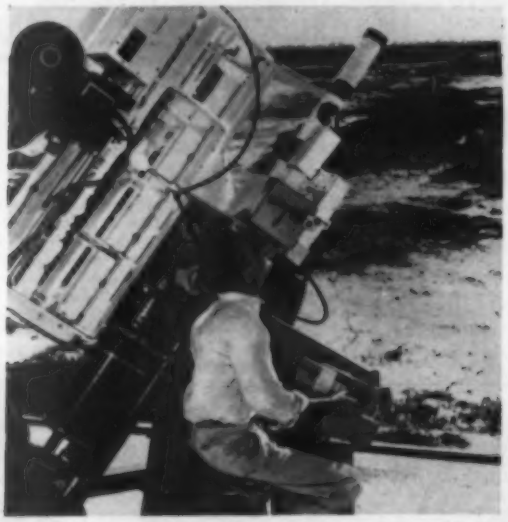
An Intercontinental Ramjet Missile

THE North American Indian tribe of this name were hardly given to striking paralyzing blows at enemies thousands of miles away, but this is the awe-inspiring function of the U.S.A.F. SM-64 Navaho missile, responsibility for which is vested in North American Aviation, Inc. Although photographs of Navaho may not yet be published, it can be stated that it is of a type which bridges the gap between existing bombers and future rocket-propelled ballistic weapons. It has wings, control surfaces, a complex guidance system and is driven by air-breathing power-plants—two large Curtiss-Wright ramjets which have already been fully developed in test vehicles flying at Mach 3 at around 100,000ft. Navaho is rocket-launched and cruises at the same height at about Mach 3.5 for a design range exceeding 2,500 miles. The airframe has already been extensively tested on turbojet power.

Navaho airframes are the work of N.A.A.'s Missile Development Division at Downey, California; guidance systems are prepared by the company's Autonetics Division and the rocket boosters and test-vehicle motors are produced by the N.A.A. Rocketdyne Division. Airborne tests of components were made at Edwards A.F.B. and Navaho flight testing is now going ahead at the U.S.A.F. Missile Test Center, Patrick A.F.B., Florida.

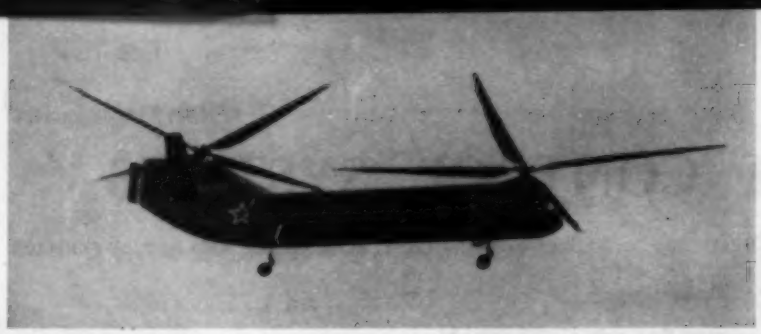


In Downey's tower laboratory (above) Navaho airframes are subjected to test loads. Another picture: December 9, 1955, p. 866.



Flight paths are plotted by a Sandia tracker (above); below, the last man off the missile "pad" gives the clearance for firing.

North American's missile-assembly hangars at Patrick are seen above; below is the central control at the Patrick Missile Test Center.



Of uncommonly good quality are these two pictures of important Russian helicopters—the twin-rotor Yak-24 and the single-rotor Mi-4, both of which were discussed at some length in our issue of August 3. The two machines epitomize Russia's remarkable technical progress in the helicopter field, as in all others.

Poland as well as in the U.S.S.R. It is intended for miscellaneous civil and military duties, including the towing of heavy gliders. The two-spar, all-metal wing is strut-braced and has a full-span leading-edge slot, slotted ailerons and slotted flaps. The forward portion of the rectangular welded-steel-tube fuselage is metal-covered and the rear part fabric-covered. The pilot is seated to starboard and a passenger to port, and there is a double seat for two more passengers at the rear. Wireless equipment is installed at the back of the cabin and for freighting or ambulance work the rear seat is removable. Stretcher cases can be loaded through a special triangular door on the port side. For agricultural work a 103-gal chemical tank is fitted in place of the wireless. The engine is a 260 h.p. A1-14R nine-cylinder supercharged radial. Principal data: Span, 39.37ft; length, 29.52ft; wing area, 236.8 sq ft; weight empty, 2,138.4 lb; weight loaded, 3,086 lb. Performance (passenger version): max. speed, 115 m.p.h.; cruising speed, 99.4 m.p.h.; landing speed, 43.5 m.p.h.; service ceiling, 13,123ft; normal range, 310 miles.

AIRCRAFT INTELLIGENCE

U.S.A.

Convair B-58. It is announced in Washington that the prototype Convair XB-58 "Hustler" supersonic bomber will begin test flying in about three months. As already reported, the B-58 is a delta-wing machine powered by four podded General Electric J79 turbojets disposed in an unusual manner and supplemented by liquid-propellant rocket motors developed by Bell. The design speed is in the Mach 1.5 bracket of around 900 to 1,000 m.p.h. This is an unusual regime to choose for a long-range aircraft. The weapons-system incorporates Blue Goose air-to-ground guided missiles which are launched many miles from the target.

Chance Vought Regulus II. Flight tests have already been successfully completed on this supersonic longer-range development of the familiar U.S. Navy Regulus target and surface-to-surface missile. Production Regulus IIs are being built against a £4.3m contract and will be used from surface vessels and submarines.

France

Marcel Dassault Etendard II. The Marcel Dassault light ground-attack aircraft formerly known as the Mystère XXII, and now called Etendard II, made its first flight on July 23. The two turbojets are Turboméca Gabizos, and the undercarriage has low-pressure tyres, permitting operation from rough fields. The designations Etendard IV and VI refer to other light attack aircraft, meeting French Air Force specifications as well as those of NATO. The Etendard IV first flew on July 24 and is fitted with a S.N.E.C.M.A. Atar turbojet. Like the Etendard II it has low-pressure tyres.

U.S.S.R.

Yak-12M. The "M" sub-type is a new version of the Yak-12 high-wing liaison aircraft, extensively used in Russia. It has a long fuselage, has been developed from the Yak-12R, and is now in production in

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AIRCRAFT CONTROL SYSTEMS

A Review from the Pilot's Angle

By CAPT. A. SPOONER AND L. F. E. COOMBS

OF the new airliners now on the market, the Comet, L-1649, Caravelle and Electra have powered or power-assisted controls. The DC-8 is a marginal case and the remainder have manual systems. Why such widely opposed schools of thought? We feel that the authors of this article present points of view which—although we do not necessarily agree with them all—help to put this interesting and widely debated topic into some kind of perspective.

NO two design teams appear to agree about controls. Consider the DC-8, the Boeing 707 and the Vickers 1000. These aircraft, all of comparable size and speed, vary in their control systems from the all-manual aerodynamically balanced system of the 707 to the split-surface, all-hydraulic power system of the V.1000. The DC-8 method, whilst similar in principle to the Boeing system, is dissimilar in detail. The Comet 4, although smaller and lighter, has single surface, all hydraulic power-operated controls.

The Britannia and Lockheed 1649 Super Constellation provide another complete contrast. Whereas Bristol favour the all-servo-tab system, Lockheed prefer their well-established hydraulic system with last-ditch manual (and muscular!) reversion. Several systems have been reported for the Electra but it is believed that that aircraft will have a basically hydraulic system [as described on July 6—Ed.]. The Vanguard, by contrast, will have all manual controls.

Approximately 1,000 Douglas DC-6s and DC-7s, 700 Lockheed Constellations and Super Constellations and 900 Boeing Stratocruisers have been built for civil and military use. Surely sufficient aircraft to provide a proving ground for the three control systems in use? Yet in their next design, the DC-8, Douglas have added to their conventional system the Boeing boosted rudder and, in addition, have boosted the ailerons. Boeing, in contrast, have abandoned in their next design their well-proved boosted rudder and gone over to the Douglas all-manual system, adding to it separate low speed ailerons. As for Lockheed, they retain their hydraulic system and continue to pay a weight penalty of about 1,000 lb per aircraft. The conflicting Electra reports indicate some degree of uncertainty about Lockheed's future policy.

An outsider may well be permitted the observation that, in spite of the importance of the subject, insufficient is known about it. It is certainly all too obvious that the division of opinion is one which cuts across international barriers. And the manual-hydraulic controversy cuts back and forth across the speed line; *vide* the 1649 and the 707. Clearly a problem exists.

As with many other mechanical advances, aircraft controls have tended to become more and more complex. Complex demands for effective control over a widening speed range result in complex equipment to handle those demands.

The aircraft of the first 30 years of powered flight operated within a speed envelope of 100 kt and control problems were relatively simple. There were no compressibility problems, buffeting or overstressing, and if controls iced up that was just bad luck—or bad piloting.

Today, by contrast, modern transports will soon have a speed range of 450 kt and will operate so near their limiting factors that momentary dives may too easily result in structural failure. Vital balance may also be upset by small ice formations in the wrong places.

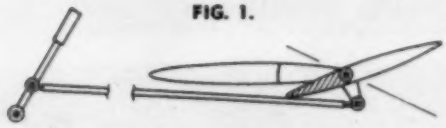
The clean shape of modern designs is such that they behave like fighter aircraft (the modern jet airliner is essentially a scaled-up Hunter) and the excessive acceleration loads induced in the airframe soon reveal structural weaknesses. It is important to note that, contrary to what might otherwise be expected, the jet transports of tomorrow contain less structural material than the older, slower types of comparable weight. This is equally true of the Comet 4, the Boeing 707 and the DC-8, all of which have empty weights considerably less than half their maximum all-up weights.

Here, then, we have our modern transport: a slim fuselage, lightly constructed, stuffed with compressed air, supported by thin wings, speeding through the air balanced upon an invisible trajectory—departure from which, unless done slowly and carefully, could bring catastrophic disaster.

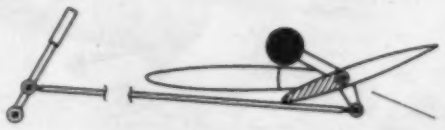
The means of change of trajectory is accomplished by deflecting the trailing edge of the supporting or stabilizing surfaces without much more refinement than the schoolboy's quick twist of the trailing edge of his paper dart. Fig 1 shows the development of control systems from the techniques of the 1900s to the present day arrangements of all-moving tailplanes and asymmetrical lift spoilers.

It is appropriate at this stage to reflect how pessimistic the

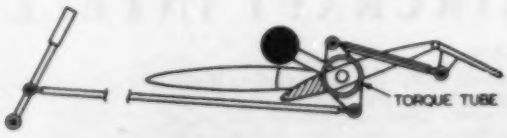
FIG. 1.



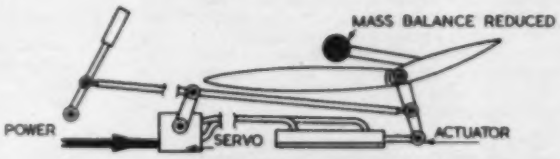
Simple manual control—aerodynamic balance is achieved by setting back the hinge.



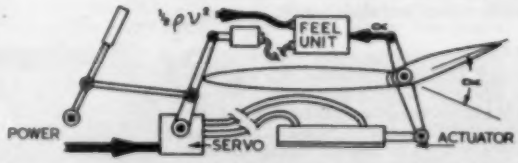
Aerodynamic balance with a mass balance added to overcome flutter.



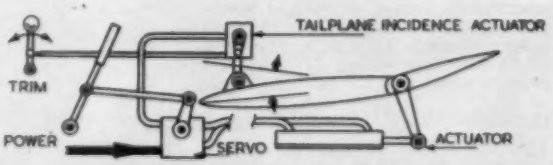
Spring-tab assistance. The tab is directly coupled to the stick; the elevator is coupled to the tab through a torque tube.



Manual control with power boost—the direct linkage is retained and part of the hinge moment is fed back to the pilot.



Fully powered elevator—the powered control is irreversible and feel is supplied artificially.



"Follow-up" tail — power is used to alter the tailplane incidence in relation to the displacement of the elevator. Operation of the trim control alters this relationship. An artificial feel unit is still required.

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AIRCRAFT CONTROL SYSTEMS . . .

theorists have been in their assessments of the air load problems as applied to balanced control surfaces. The first practical air transport to be fitted with a power boost system was the Lockheed 49 of 1939. The innovation did not occasion excessive comment at the time. That was partly due to war-time security and partly due to the then accepted fact that such a huge aircraft (75,000 lb originally) travelling at the "fighter-like" speed of nearly 250 kt, had passed the limit at which manual forces could be practicably applied.

Some 20 years later, the Boeing 707-320 is being ordered at the all up weight of 295,000 lb and with a cruising speed of 500 kt. Yet the control system is basically a manual one, aerodynamically balanced.

Whatever the theorists may say, the 707 not only flies but has been slow-rolled. As a breed of practical men, pilots prefer the evidence of their own eyes to that of someone else's slide-rule.

From the pilot's point of view, the suitability of a control system is first assessed by considering its reliability. The yardstick is the reliability experienced in 50 years of flying with a direct mechanical linkage between the control column and the control surfaces. In addition, a control system is assessed on its ability to feed back to the control column an accurate representation of the loads on the control surfaces such that the pilot cannot inadvertently overstress his aircraft.

The designers, however, whilst accepting all this and the views of the slide-rule theorists, are of the opinion that for any aircraft which has to cruise at high Mach numbers it is much easier to develop a powered control system than it is to develop a balanced manual system. Power systems can be developed that are irreversible. Manual systems could result in both flutter and control reversal. In fact, until Boeing proved otherwise, designers were in general agreement that, for the immediate future, control without power was a practical impossibility for Mach 0.7 and above—beyond the means of normal manufacturing tolerances and beset with servicing problems which no normal operator could accept.

The customer is very often right. So, before proceeding with descriptions of the various types of control systems, a look into the future orders books might be enlightening.

Fig. 2 shows the extent to which the two major classifications of

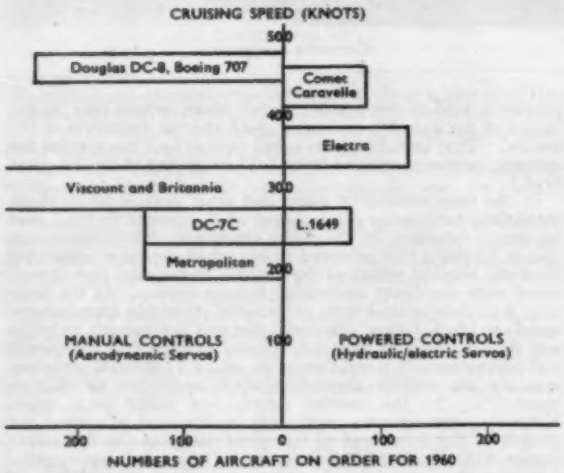


Fig. 2. "Balance of power" in numbers of aircraft on order for 1960.

controls, power and manual, will be used in 1960. The index of influence has been derived from the sum of the numbers of the different types of modern transport aircraft expected then to be in service. The index is plotted aganist maximum cruising speed to show at each band of speed the "balance of power" between manual and power systems.

It is interesting to observe that the top speed section of the table is dominated by the DC-8 and the Boeing 707. It could be argued that the DC-8 should be placed in the power rather than manual division, since the only elevators are all manual and the ailerons and rudder are power assisted. However, Douglas emphasize that "power is not necessary to fly the aeroplane."

When comparing British and U.S. control trends, it is necessary to consider the differences between the resources of the two countries. The limited resources in this country might well be the dominant factor accounting for the different systems now being fitted to the latest Vickers and de Havilland aircraft. When the Comet was first being constructed, there was no experience at hand for an aircraft of that size and speed. The Vanguard, however, being produced at a later date and designed for less critical speeds, can draw upon the experience of the V-bombers, the Viscount, the Britannia and the Comet itself.

The technical barrier of time can only be conquered by having adequate experience and resources. Otherwise revolutionary processes become gambler's throws.

This situation should then be compared with America's advantages of having quantitive superiority in money, military orders and brains (not necessarily better brains) with which to evolve a logical manual system for a high-speed transport. The question then arises: why do not Douglas go for an all-manual system in view of their unrivalled experience in this field? The answer might be that the firm had to have a competing transport to prevent Boeing from sweeping the world markets and had, therefore, to develop a control system quickly. In other words, they had to build a system which could be made perfect on ground-rigs without the necessity for extensive flight-testing. It must be remembered that Boeing have accumulated a mass of experience with high-speed jets, such as the B-47, which, although fitted with power controls, has a manual reversion system. It is generally believed that their present manual system, as fitted to both their 707 and B-52, was evolved from the efforts made to refine the manual side of the B-47's system. It is possible that, in the years ahead, for follow-up aircraft to the DC-8, Douglas will be able to do the same, once sufficient flight experience has been accumulated on the early DC-8s.

Let us consider now the effect of speed on a control surface. The elevator will be given the most attention as it is the surface which can cause the pilot the most trouble, either through a lack of elevator control or as the means, inadvertently, to overload the structure in some manœuvres.

As with the airspeed indicator, the predominant effect of the airflow is found from the square of the speed, as defined in the well-known expression $\frac{1}{2}\rho V^2$. Therefore, as the speed increases, the airloads upon a control surface will increase as the square of the speed.

With the older aircraft, the designer could evolve a system which operated successfully throughout the limited speed range, with the result that the aircraft of 1920 with direct manual controls and a 100 kt speed range could have its control characteristics decided by the rigger by rule-of-thumb procedures. With a large speed range the problem is very much more complex.

At low indicated speeds the effort required at the control column might be ten pounds to alter the elevator angle by one degree. Assuming the designer had, by the introduction of a power boost system, kept the effort per degree of surface movement constant throughout the speed range, then a nonchalant ten pound tug on the elevator control would pull the aircraft apart. If the designer arranges the characteristics of the control system to suit the mid-range of speeds, then the extreme speeds will suffer. At low speed, when effective control is essential during the approach, the controls would be "sloppy" and at high speed "hard."

As speeds increased, the designer modified the control system and surfaces to maintain the effectiveness of the controls throughout the speed range. As has been seen, at first the task was easy, as the pilot could be expected to make any adjustment to the amount of control displacement, or to the push or pull he exerted upon the stick. Later, an aerodynamic balance was added which made the airstream do some of the balancing work. For obvious reasons, only a proportion of the airloads on the main part of the control surface would be balanced; therefore, with increasing speed, the aerodynamic balance had to be abandoned along with mass-balance weights which moved proud of the main surfaces. Also aerodynamic and mass balances added to the ice problems associated with modern flying. Ice formed on the leading edge of the balance and upset the calculations. Ice also formed in the large hinge-gaps left exposed by aerodynamic balancing.

The next control refinement carried the designer up a big step in speed. This was the servo and booster tab. The servo tab came into use early on in aviation and was a feature of most large aircraft, some of which had as many as three rudders to overcome the resistance to turning of a forest of struts, wires and nacelles, not to mention wing-mounted stability fins.

The servo tab was essentially a simple solution to the early problems of control loads. As the surface displacement angle increased the airloads increased. At the same time the servo tab was moving in the opposite direction, thereby balancing out part of the surface loads. From there it was a logical step to connect the pilot's control wire, or rod, to the tab and not to the main control surface. The pilot now displaced the tab in the opposite direction to the intended control surface movement, thereby unbalancing the system so that it moved in the required direction. This system had the advantage that as the angle of displacement reached the limiting position the servo tab was blanketed by the

AIRCRAFT CONTROL SYSTEMS . . .

surface, thereby tending to restore the controls to neutral. The most usual boost tab arrangement was the spring tab, which could be displaced by a certain amount to operate the main surface until the tab controls had overcome a spring in the circuit. Thereafter, further movement of the controls operated the surface directly until a reversal of effect was required. The spring was then unloaded, the tab centred in relation to its surface, and the spring compressed in the opposite direction. The torque tube was the usual method of providing the spring.

The spring tab control system proved effective until, with increasing speeds, it tended to lose its effect and, in some cases, became more trouble than it was worth. The direct all-tab system also suffered at low speeds due to the insufficiency of the air loads upon the tab surface.

The introduction of the autopilot and an increase in the size of transports in the 1930's resulted in the adoption of power boosted control systems. The control loads were proportioned between the pilot's direct linkage and the power circuit so that only a proportion of the loads were fed back to the pilot. The power boosted system was accepted by pilots without adverse comment because the direct mechanical linkage between the control column and the control surface was retained. In addition, the boffins thought that manual control systems for high speeds would need excessive development time, particularly flying time and money to achieve. The boosted systems became for a short while an accepted method of overcoming increased loads as weight and speed increased, and were used on many high speed jet aircraft.

The first and major problem that arose concerned manual reversion—the problem occurring when the power failed and the pilot was left with a simple direct-linkage system. He was then confronted with loads much greater than usual, so the designer had to balance the system to allow for an acceptable degree of abnormal control forces for emergency use. Most power boosted systems had the loads divided so that the pilot had to give one pound of push or pull for every three pounds provided by the booster.

This 3 to 1 ratio did enable the pilot manually to control the aircraft under most situations; it took effort but it could be done. However, with military aircraft it became apparent that if the power should happen to fail at a time when the aircraft was in an abnormal flight condition (as can easily happen in combat when bullets are being sprayed around) the physical effort to right the aircraft was beyond the strength of the pilot.

Another problem which arose as the speed range increased with the introduction of gas turbine power was the amount of feel to be fed back to the pilot. If this was proportioned to give satisfactory feel during cruise conditions, the proportion for the approach and landing speeds produced was insufficient, and gave an impression of sloppiness at a most inopportune time. It is a fact that in spite of great efforts by the designers a simple artificial feel system, such as one utilizing springs, has seldom satisfied the pilot. At best it is a poor substitute for the real thing.

Apparently without considering the psychological aspect, the designer next eliminated the mechanical linkage between the pilot and the control surfaces. Now the pilot could well have been provided with a switch marked "up" and "down" instead of a control column. In the place of all the wheels, pulleys, brackets, springs and wires, a few obedient hydraulic or electric motors mounted close to the control surfaces were deemed sufficient. However, in the pilot's mind, leaking or burst pipes or fused or failed electrics were a poor substitute for the sturdy length of tubing or tough wire cable which he had learned to trust over a period of years.

As the full-powered system gave no indication to the pilot of the loads at the control surface, it became all too easy to overstress the aircraft. The input loads to a full power system needed only to be a few ounces, just enough to operate a switch or a servo valve. An advantage to the designer was that the autopilot output loads could be very much smaller and, therefore, the autopilot installation could be very much reduced in volume and weight.

The question of feel now became all-important for safety as well as convenience.

The first attempt to provide feel for power systems was to incorporate a spring which would give increasing resistance to control column movement with increasing control surface displacement. Unfortunately, although such an arrangement prevented the pilot applying say four degrees of elevator at low speeds, it did not prevent him applying one degree at 500 kt; and one degree at that speed is more than equivalent in its effect to four degrees at 100 kt. Accordingly, the designer had to

Caravelle—powered.

provide a load to the pilot's control which would vary as the square of the aircraft's indicated speed and the deflection of the control. That introduced the q-feel device. (q is the symbol for dynamic pressure, derived from $\frac{1}{2}\rho V^2$ as measured by the pitot head.)

By the incorporation of q-feel and other devices which made corrections for angular displacement of the control surfaces, and for other variations in the flight conditions, the designer was able to develop a fully-powered system which produced somewhat the same physical effects at the controls as the pilot had experienced with the direct mechanical linkage system. At the same time it allowed control to be maintained effectively from runway speeds to Mach 1 plus. However, that was not enough, as pilots and certain operators were not entirely satisfied that statistically and psychologically it was correct to send a £1,000,000 aeroplane into the air entirely dependent upon hydraulics or electro-hydraulics. So the manual system was added once again. Naturally, such systems could only be designed to control the aircraft at the lower end of the speed range as the full power system had eliminated the necessity for mass and aerodynamic balances; thus the manual system was either very sloppy or required excessive physical effort.

The designer did not take kindly to having to provide a manual reversion system as it was then necessary to take steps to ensure that the control system when on manual flight would not be subject to flutter effects. In any control system in which all or some of the control loads can be fed back to the pilot's control accurate balancing is required if flutter is to be prevented.

A further point that the designer had to consider was whether the manual system compromised the safe working of the power system.

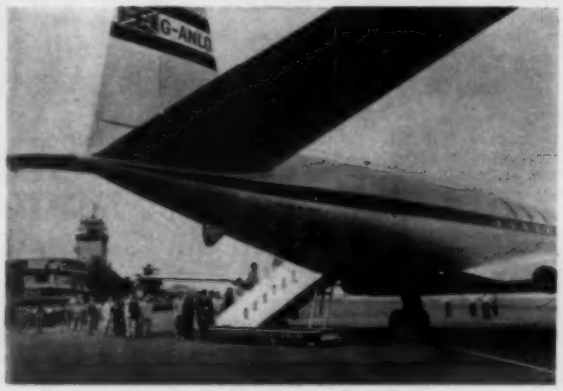
High speed aircraft demand a stable control system, be it manual or power. The system must not be disturbed by flexing of the structure which displaces the mounting brackets and hinge centres. At the same time all components, particularly those of the power system, must be as reliable as the direct mechanical rod or wire and capable of self-damping to prevent unwanted control signals reaching the control surfaces when flying at high speeds. A further problem introduced with high speed aircraft is that wing bending and twisting tends to disturb the airflow over

Boeing—manual.

the ailerons. This is especially noticeable with aircraft having high-aspect-ratio wings.

As has been stated, the pilot is not willing to give up the existing manual control system unless the power system can be shown to be as safe and reliable as the direct rod or wire cable arrangements. Obviously, one way to prevent the disaster of losing elevator control (as an example) is to duplicate or further multiply all the power control system and the actuators and provide alternative sources of power to guard against the possible loss of a "vital" engine. That is a relatively easy solution, except that if an actuator fails or locks solid it might prevent the operation of the stand-by actuator so that all the multiplication of control pipes, wires and servo-valves is of little use. The actuator must be designed to float or disconnect from the system should it fail.

The safest arrangement might be to take the multiplication to its logical conclusion and divide each control surface into two, three or four independent sections. Each section would have its own actuator with an independent control circuit and its own source of power and fluid. On such a system, for example, the elevator would be split into four sections, two to port and two to starboard. Each engine of, say, a four engined aircraft would have two pumps (a total of eight) which could be grouped and



Comet—powered.

selected to provide duplicate power to all four actuators. The chances of a complete loss of control would then be so remote that there would obviously be little cause to demand that a manual reversion circuit be fitted. The control system would also be unaffected by engine failures. Experience alone will enable the designer to determine how few independent systems are acceptable for safety.

At the present time the designer has a number of control systems available for incorporation in an aircraft, and depending upon the speed range and function he selects various combinations of full power, boosted and manual circuits. Alas, no two designers make the same decision!

Neglecting the figures in the salesman's order books, the Comet 4 and the Boeing 707 stand as examples of opposite schools of control thought. The Comet 4 will have a full power system for all the primary control surfaces, with duplicated actuators and duplicated hydraulic power supplies plus emergency electric pump. In contrast, the 707 is fitted with a manual system. At low speeds an additional set of ailerons come into use. The only power used is for the spoilers, whose job is to ease the pilot's burden. In no way can the spoilers be regarded as essential. Even the adjustable tailplane can be manually operated.

It will be interesting to note in the future how the two systems cope with the job of controlling these 500 kt transports. Experience shows that the Boeing 707 handles beautifully throughout all the speed ranges, which is a good advertisement for manual control.

On the other hand the Comet 4 will have hydraulic power-operated ailerons, elevator and rudder; all of the surfaces will have mass balances. Feel for the ailerons and the rudder will be provided by springs which will give an increasing load at the pilot's control as the control surface deflects. However, the load will not be directly related to airspeed.

In contrast the elevator control circuit will incorporate a q-feel device thereby giving increased control loads with both surface deflection and increasing airspeeds plus a lower break out force than was used on the Comet 1.

To sum up: A pilot needs responsive controls for take-off and landing speeds. These controls will have to be capable of immediate and large displacements. For the climb and cruise he requires controls which will be capable of firmly but smoothly changing the path of the invisible trajectory along which his bullet-like machine rides. These controls must not, however, be sensitive to accidental knocks and jars as are inevitable in the crowded cockpit space in which he works. Nor must the controls be such that at high speeds any large and sudden displacements are possible. Yet control must be effective under all conditions of flight, including those when wing distortion is present. In addition, at all times the system must resist flutter and possible control reversal. It must also be proof against any ice accretion which can either jam the hinges or upset the balances.

Further, the pilot expects that a reasonable proportion of the design-energy of a manufacturer is directed towards the auxiliary functions of the primary controls. As an example, the ailerons are not only used for roll control and for applying asymmetric lift when an engine fails, but also for maintaining direction under runway cross-wind conditions or on icy or greasy surfaces. The rudder must be capable of combating the adverse yawing moment at that most critical phase of flight, an engine failure on take-off. The elevator must not be too dependent on the slipstream for its effect. Obviously, the primary control of a high speed aircraft can no longer be considered as a "private" system entirely divorced from engine and propeller characteristics and pitch changes induced by different settings.

On top of this the pilot requires, both for his peace of mind and for passenger safety, the knowledge that barring Acts of God, the control system will stand up to every force that the trained pilot will normally apply to it. There must be no question at all about the system's ruggedness or reliability.

Lastly, at all times the pilot requires a constant degree of "feel" so that his hands and physical senses will convey to him early signs of increased control loading.

How is the pilot to get all this?

Thinking clearly, the most important fact which stands out is that the Boeing 707 and the B-52 have demonstrated that up to weights of over 400,000 lb and Mach numbers of 0.96, cable operated manual control systems (internally aerodynamically balanced and assisted by well-tried spring tabs) are still capable of doing the job for which they have been designed. The pilot is supplied with ruggedness, reliability, natural feel and freedom from ice accretion. Basically this is the system for both the 707 and the DC-8.

These systems, unaided, are satisfactory for the cruise and climb case, but they fall short of the ideal requirements in meeting some of the specialized problems associated with speed at both top and bottom of the speed range.

To meet the low-speed case Boeings have fitted an additional set of ailerons which make up in area what is lacking in airflow. Douglas in contrast have designed ailerons specifically for the normal airflow and have added power for more low speed displacement. They have also added power to the rudder specifically to meet the engine-out requirements and to permit greater angular throw during cross-wind landings.

At speed both aircraft make use of adjustable tailplanes for the purpose of better maintaining fore-and-aft stability and to counter the longitudinal trim changes which occur at high Mach numbers. A point which will appeal to all pilots is that in the 707 this adjustable tailplane can be mechanically actuated. For

Convair—manual.

AIRCRAFT CONTROL SYSTEMS . . .

high speed lateral control, when ailerons tend to be subject to unsteady forces as well as high operating loads, Douglas call upon the assistance of hydraulically operated air brakes situated on the upper surface of the wing. For this use they function as lift spoilers. These various additions are refinements rather than essential components and Boeing's Tex Johnston has publically stated that the aircraft can be flown under all normal conditions with the "extras" inoperative. The difference is in the degree of effort required. Douglas made similar declarations.

It seems, therefore, that the case for a power assisted primary system has collapsed in the face of care and diligence in design, supported by practical experience and backed by adequate resources.

This is not intended to imply that the end of the trail is in sight. The day may eventually dawn when aircraft will attain speed and size of such magnitude that long proved methods will no longer be applicable. Then (it will probably not be until the 1970-1980 period) surely all existing practices will be abandoned and new concepts instituted? Power as a primary source of control is hardly likely to fit into a system evolved during some 70 years of manual experience and based safety-wise upon the infallibility of steel cables, or push-pull rods.

It is any man's guess what will be fitted in 20 years' time. But the pointers at present are indicating two lines of thought. One, that the control surfaces will have to be split into multiple units both for control sake and for safety reasons. Each unit would be entirely independent as to actuators, fluid supply (if any) power sources, etc., and they would have to be so designed that adequate control could be maintained with two units inoperative in much the same manner as adequate thrust for a four engined aircraft can be maintained with two engines out.

Or, more likely, control surfaces as we know them today, will be scrapped along with the linkages to them and the atomic powered flying machines of the future will obtain their manœuvrability and stability in space by reactive jet forces. So far only thrust is supplied by this principle, but lift and control could well follow suit—engineers on both sides of the Atlantic are already experimenting along these lines.

ALL THE GEN

TWO enterprises in tracing and collating Air Force slang are being undertaken, one in this country and one in the United States. At Maxwell U.S.A.F. base, Alabama, a dictionary has been prepared (according to a Washington report) of words and slang used by the U.S.A.F.

In a foreword, the editors carefully explain that "although the language of Air Force men is indeed English, a certain part of it is in the nature of a special usage." Thus, an "amiable cluster" does not indicate a friendly gathering of humans but "a cluster of bombs, especially fragmentation or incendiaries, held together so as to be aimed and dropped by ordinary bomb methods" (we should question the spelling of the adjective—amiable or aimable—in this context). "Dawg" means "dynamic war game" and "bingo"—also used in the R.A.F.—is a radio call to a formation leader, signifying that a previously agreed fuel state has been reached.

Meanwhile, two professors from Cologne University are in England trying to trace the origins of R.A.F. slang. They are Professors H. Bueckendorf and Buchloh; and before leaving Germany they supplied H.Q., 2nd A.T.A.F., with a glossary of war-time German Air Force slang.

FRANCO-BELGIAN CO-OPERATION

THE French S.N.C.A.S.O. company has announced an agreement with the Belgian S.A.B.C.A. (Société Anonyme Belge de Constructions Aéronautiques) covering the production of certain unspecified S.O.4050 Vautour components by the Belgian concern. The agreement has been reached "within the framework of European co-operation" through the Association Internationale des Constructeurs de Matériel Aéronautique. The Belgian company's work is to occupy several hundred workers and components will be destined for all Vautours ordered both by the French government and from abroad. Co-operation may eventually extend to new projects now being studied.

HORSE-SHOE AND MAPLE LEAF—A T-33 SILVER STAR OVER NIAGARA

FRAMED by the stupendous horse-shoe falls at Niagara is this Canadair-built Lockheed T-33 (known in Canada as the Silver Star) wearing the maple leaf insignia of the Royal Canadian Air Force. The engine is the Rolls-Royce Nene, and to date Silver Star production totals over 550. Further orders are in prospect for this excellent U.S./Canadian/British jet trainer.

THE INDUSTRY

W. R. McLachlan Orenda President

THE chairman of Orenda Engines, Ltd., and president and general manager of A. V. Roe Canada, Ltd., Mr. Crawford Gordon, Jr., has announced the appointment of Mr. Walter R. McLachlan as president of Orenda Engines, Ltd. Mr. Gordon himself previously held this post.

Mr. McLachlan, formerly vice-president and general manager, retains his duties as general manager. He joined Orenda in 1953 and is a director of the company and of A. V. Roe Canada, Ltd. He was born at Leeds, Yorkshire, in 1904 and was educated at public and high schools in Toronto.

Periscopic Inspection

FROM P. W. Allen and Co., of Liverpool Road, London, N.1, comes information on new Bodson periscopes, for which they are sole agents in the U.K. These inspection instruments can be employed in situations where visual observation is difficult or dangerous, and among suggested uses for them are studying models in wind tunnels or aircraft controls while test flying.

Normal diameter of the periscopes is approximately 1.2in, their total maximum length approximately 25ft. A variety of bends can be introduced, giving a field of view of 45 deg-50 deg; but magnifications up to eight times are possible if the angle of view is reduced to 6 deg.

Testing Refueller Filters

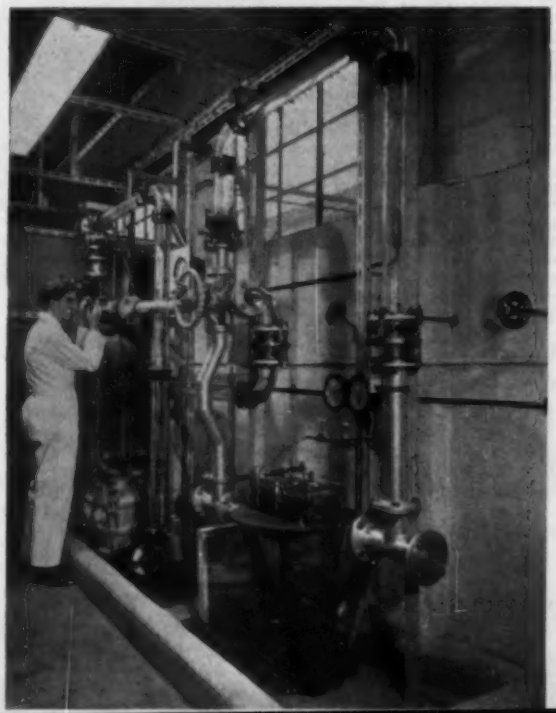
ILLUSTRATED below is a full-scale test-rig which the British Petroleum Co., Ltd., have installed at their Sunbury research station in order to study flow and separation efficiencies of the filters employed in their aircraft refuelling equipment.

To eliminate unwanted foreign matter (as distinct from artificial contaminant) all pipe-lines are made from glass or tinned steel, and the storage tanks, each with a capacity of 1,000 gal, are made from stainless steel. The fuel is pumped by a Pegson centrifugal unit with electric motor drive and is capable of variable rates of flow up to 260 Imp. gal/min. Rate of flow and total fuel passed on test is indicated on an Avery-Hardoll flowmeter and an integrating meter.

Tests are carried out to a standard technique with 1,000 gal of aviation turbine fuel, either by re-cycling from one tank or by transferring from one tank to the other. An auxiliary filter is included in the system for pre-cleaning the kerosine and during a test the required measured quantity of artificial contaminant is introduced into one tank, raised into uniform suspension by pumping from one tank to the other several times, and then passed through the test filter. Samples of feed and filtrate are taken by pitot-tube immediately ahead of and downstream of the filter, and facilities are provided for measuring the line pressure and differential pressure across the filter during the test.

In addition to the assessment of filters, the rig is also used for water-separator efficiency tests.

The B.P. filter test-rig described above.



Visitors from Canada: Examining components of the Orion turboprop engine during their recent visit to Bristol Aero-Engines, Ltd., are Mr. Douglas James of Orenda Engines, Ltd. (centre), and (on the right), Mr. Earl Busby. With them are (left to right) Mr. W. E. Wright, chief planning engineer (production) and Mr. W. C. Edmunds, chief planning engineer (development), Bristol Aero-Engines, Ltd.; and Mr. Jack Schettler of Bristol Aircraft (Western), Ltd., Winnipeg.

Bristol Appointments

FROM Bristol Aircraft, Ltd., comes an announcement of two new appointments to their Board. Mr. T. B. Pritchard becomes financial director and Mr. G. E. Knight commercial director. Mr. Pritchard, who has been chief accountant of the Bristol Aeroplane Co., Ltd., since January 1953 is succeeded in that position by Mr. G. A. Harrison, previously assistant chief accountant. Mr. Knight, who has been secretary of Bristol Aircraft, Ltd., since its formation in September 1955 is succeeded by Mr. A. D. Cawse, previously secretary of the Weston Division of Bristol Aircraft, Ltd.

Mr. G. Hanby, secretary of Bristol Cars, Ltd., takes over the secretaryship of the Weston Division from Mr. Cawse; and Mr. Hanby has been succeeded by Mr. F. S. Derham, who has been works accountant of Bristol Cars, Ltd., since November last year.

Mr. T. B. Pritchard, who is 42, joined the Bristol Aeroplane Co., Ltd., in August 1952 and was appointed chief accountant in the following January. Before the war he was engaged on professional work as a chartered accountant, partly in South Wales and partly in Spain and Portugal. After demobilization from the Army, he joined a London firm of accountants.

Mr. G. E. Knight, who is 35, joined the aircraft division of the Bristol Aeroplane Co., Ltd., in 1953 as assistant divisional secretary, becoming divisional secretary in 1955. He was appointed secretary of Bristol Aircraft, Ltd., on its formation in 1955.

Precision Electrics

THAT precise control equipment requires precise manufacture is well understood at the two factories at Willesden and North Acton, where Vatric (Control Equipment), Ltd., are ably backed by Vatric (Precision Tools), Ltd., in the quantity production of a range of small A.C. and D.C. electric motors, D.C. generators and reduction gearboxes. The constant demand for ever-smaller servo components, particularly within the confined envelopes of guided weapons, can only be met by increasing efficiency to a very high level, and this in turn must be achieved by very close-limit manufacture and strenuous test. So important is the Vatric equipment within the loops of many servo control systems that the company do not permit themselves any compromise on short-life missile application—each motor is passed-off for 1,000 hours' working life.

Considerable importance is attached to research and development for both the organization and, under contract, for the M.o.S. Typical of the "pure research" programme is a current investigation into lubrication and electrical insulation at elevated temperatures, and high-altitude brush wear, while useful development work is being done on items such as a standard range of gearheads to R.A.E. specifications.

Very small precision gearboxes with reduction ratios of up to 10,000:1 pose severe production problems when the backlash must be limited down to 20 minutes of angle. The manufacturers claim that watch-making precision compares unfavourably with these motor gearheads, since the output torque of a watch is considerably less, and backlash—being uni-directional—presents no problems.

Manufacture of the motors demonstrates many examples of the ingenuity used to solve particular problems of accuracy and concentricity. A good example is the production of completely burr-free laminations from nickel steel strip. The required pressing tool is in the form of a series of small radially disposed keyhole slots, through which must be pressed a series of mating

THE INDUSTRY . . .

punches—but with the absolute minimum clearance if no burrs are to be formed. Since it would be very difficult to machine these slots sufficiently accurately, the tool is formed from a series of segments each side of which is machined to the shape of half the required slot. The segments are then pressed into a base plate and machined-off flush.

Another Vatric tool is an induction heater which melts pure aluminium for the induction motor rotor slots. The rotor bars are then cast into position centrifugally in a rotating mould. Most parts of the motors and generators require to be finished by internal or external grinding.

Winding and assembly require special care to ensure that the electrical insulation on each wire is not marred. Some of the finest winding work—on the A.C. stators—relies on the dexterity of girl operators, although the windings for D.C. machines can be done mechanically. Assembly is done in special dust-proof cabinets, supplied with filtered air. Among the electrical and mechanical tests which are carried out on each motor is a noise-level check, although all armatures are balanced against vibration.

The specialized and expensive machine tools which the precision firm requires for its servo-motor work leave a margin of useful machining capacity for jigs and fixtures, press tools and dies for the aircraft (and automotive) industries. Diverse examples are the sinking of forging dies for Bristol gas-turbine blades, close tolerance jig boring of Armstrong Siddeley magnesium-alloy engine casings, and a remarkable steel helicopter rotor hub, which during machining from the solid is reduced in weight from 575 lb to only 52 lb.

IN BRIEF

The Plessey Co., Ltd., has formed an American corporation to represent its interests in the U.S. Known as Plessey Incorporated, it has as president Mr. W. J. Sinsheimer; its offices are at 41 East 42nd Street, New York City. The Plessey offices in Chicago have been closed.

* * *

Detuners, Ltd., specialists in the silencing of engine test plant, announce their removal to larger premises at 58 Highgate West Hill, London, N.6 (Fitzroy 1221).

* * *

The Board of Imperial Chemical Industries, Ltd., declaring their agreement with the policy of price restraint advocated by the Federation by British Industries, have decided to make no further increase in the home trade prices of many I.C.I. products, including paints and plastics, at least until June 30 next year. As production costs of certain other I.C.I. products, particularly those involving non-ferrous metals, depend on imported raw materials which fluctuate widely in price, the Board say that for these they "can do no more than continue their policy of price restraint."

* * *

It was recently announced in this column that Edward A. Pearce and Partners, of 28 Baker Street, London, W.1, have taken over the practice of the late Mr. H. Q. A. Reeves, the engineering consultant who lost his life whilst testing ground silencing equipment. We are asked to make it clear that the firm have taken over the whole of Mr. Reeves' practice with the exception of heating and ventilating work for certain clients with whom it was agreed that Mr. Greatorex, of Berners Street, should continue to deal.

CORRESPONDENCE

The Editor of "Flight" is not necessarily in agreement with the views expressed by correspondents in these columns; the names and addresses of the writers, not for publication in detail, must in all cases accompany letters.

First Women to Fly

IN 1907, when man first began to try his wings (almost exclusively in France) only the best of the quaint contrivances of those days would lift the weight of its own pilot, consequently lifting the weight of a passenger was utterly out of the question. But improvement moved apace, and by 1909 the Voisin (better known as the Farman) "box-kite" could carry a not-too-heavy passenger. Before this, however, the Wright brothers' machine could carry two, and had carried the first woman ever to fly in an aeroplane, in the person of one Mrs. Hart O. Berg, wife of the American who financed Wilbur Wright's demonstrations at Le Mans in France in the summer of 1908.

A recent obituary notice in a London newspaper records the death of Dame Ethel Locke-King at the advanced age of 92. She was the wife of Mr. H. F. Locke-King, constructor and owner of the erstwhile Brooklands automobile racing track, the centre part of which subsequently became Brooklands Aerodrome. After the flying meeting at Blackpool in October 1909, Mr. Locke-King invited one of the competitors, to wit, M. Louis Paulhan (later the winner of the *Daily Mail* £10,000 prize for a flight from London to Manchester) to give some demonstration flights at Brooklands. At this function, the writer was standing close to a small knot of people, one of whom was Mrs. Locke-King, later created Dame for her services in the 1914-18 war. Through an interpreter, Paulhan asked her if she would like a flight. She accepted with alacrity, climbing up to a small seat behind Paulhan in the Farman box-kite with the agility of a schoolboy. Thus, this lady was the first British woman to fly in an aeroplane in Britain, since none flew at the preceding Blackpool aviation meeting, at which practically all the contestants were Frenchmen, flying French machines. Of the few British machines entered for this contest (Cody was absent) not one could even fly! However, they provided a comic interlude, much to the delight of the more ribald of the spectators.

London, S.W.17. E. V. HAMMOND.

Airline Flight Separation

IN the early days of airline flying there were so few machines in the sky that the risk of collision was small, and random separation was perfectly safe. Quadrantal height separation was later introduced, and currently the three most common types of en-route separation are by (1) Airways; (2) Advisory Routes; (3) Oceanic type of control.

It is taken for granted by many people that these methods are necessarily safer than random separation, but this assumption may well be mistaken. Even the third method, where each aircraft flies in a buffer of airspace a billion times its own size, leaves much to be desired. For example, a writer in *Aviation Age* in May claimed that Oceanic A.T.C. is an unreliable and blundering instrument, and tended to the view that random separation might be accepted as an alternative.

There can be little doubt that Advisory Route separation is more hazardous than Oceanic; can we, then, consider that A.D.R.s give any improvement on random separation? Where the system can be criticized is that it concentrates aircraft along a narrow route instead of allowing them to spread out as they otherwise naturally would on long stages. This method, which results in a narrow and highly congested airspace whilst at the same time leaving almost all the air completely empty, is adopted to a large extent to clarify the work of the advisory service. Its inherent defect is that it puts complete trust in human and instrumental accuracy. It brings the aircraft deliberately close together, and blindly assumes that nothing will go wrong.

Two recent developments have shown the danger of this assumption.

The first of these has been the publication of the I.F.A.L.P.A. report on altimeter error. This report has demonstrated just how dangerous an instrument is, and how risky it is to rely upon it for vertical separation at higher altitudes. Yet Advisory Routes deliberately abandon horizontal separation, and put implicit reliance on the altimeter.

The second development was the June collision over Grand Canyon. This disaster, the worst in U.S. airline history, was apparently due to two aircraft converging on a radio beacon. Whilst we shall have to wait for the official explanation of the accident, it does seem probable that but for closing over a check point these aircraft would not have been near one another (they had been airborne over an hour, and were bound for different destinations). These two machines were near the middle of one of the famous deserts of the world; there was plenty of room for them to spread out. It looks remarkably as though the accident was caused by the very system which was designed to prevent it.

Many advisory routes have been established over the deserts of Africa and Asia during the last two years. In my experience their indiscriminate introduction is viewed with alarm by most of the pilots who have to fly them. They are no improvement on the century-old railway signalling system, and can never be the ultimate answer to flight separation. May I therefore reiterate my plea for A.D.R.s to be regarded with the greatest suspicion until collision radar, V.O.R., Dectra, or some other device provides for three-dimensional separation?

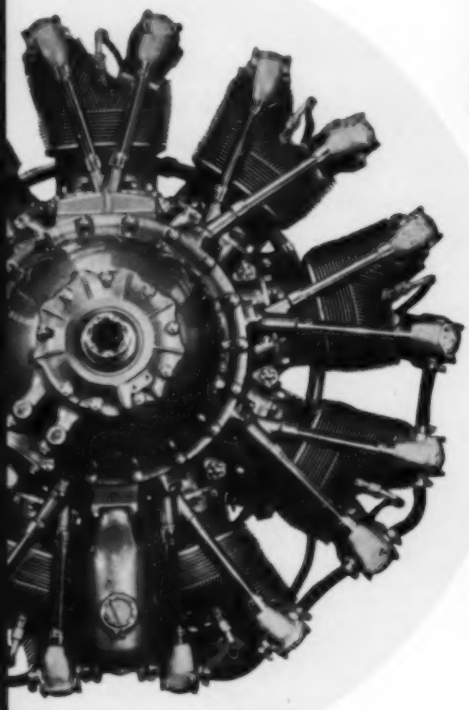
Maidenhead, Berks. AIRLINE CAPTAIN.

Good—but not that Good

I WOULD be very grateful to have any information about the secret Dart-powered aircraft now flying in such great numbers as to bring total Dart flying hours to 100,000 a week (*Flight*, July 20, page 132).

Fonteny par Andelot, France. A. KATANY.

[Nothing secret. "Per week" should, of course, have read "per month."—Ed.]



A quarter of a million hours in Royal Air Force Training Command

The Alvis LEONIDES Engine was chosen by Royal Air Force Training Command to power the Hunting Percival Provost after the most gruelling series of tests ever undertaken by a basic trainer.
After more than a quarter of a million hours in squadron service, the Leonides is acknowledged to be the most compact, dependable radial engine in its power range.

ALVIS **LEONIDES** 550 b.h.p. radial

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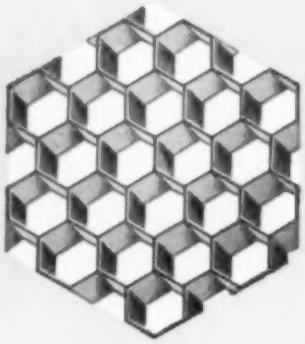
Worth its weight in . . . ?



For many structural applications there is no material to compare with metal honeycomb core bonded to metal skins. "Sandwich" constructions of this kind enable weight savings on a considerable scale to be used for improved payloads, and . . . the saving is achieved without detriment to strength or rigidity.

'Redux' adhesives make sandwich structures possible. 'Redux' Film 775 R simplifies the bonding of metal skins to honeycomb cores and now we are producing the honeycomb itself. Aero Research honeycomb is supplied in cell sizes of $\frac{1}{8}$, $\frac{1}{4}$ and $\frac{3}{8}$ in. inscribed circle, each available in wall thicknesses of .001, .002 and .003 in. It is made in a range of depths.

Our seventeen years' experience of honeycomb structures is at the disposal of designers and production engineers. Honeycomb information sheets will be sent gladly on request.

HONEYCOMB CORE

Aero Research Limited *A Ciba Company, Duxford, Cambridge. Sawston 187*

SBAC

AP. 264-209

The second Herald, pressurized and closely representative of the production aeroplane, took the air for the first time on August 14 (just within a year of the prototype's maiden flight). S/L. H. G. Hazelden, H.P.'s chief test pilot, flew the aircraft, which will be shown at the S.B.A.C. Display in Handley Page colours.

CIVIL AVIATION

BY BRITANNIA TO AMERICA

MR. PETER MASEFIELD, managing director of Bristol Aircraft, was due last Wednesday to give a luncheon address at the Air Transportation Meeting (see p. 265) at San Diego, California. He took the Britannia with him, having for some months been planning to demonstrate its capabilities to the world's biggest airliner market.

Flown by a B.O.A.C. crew of seven (with a cabin crew of five), the Britannia concerned is the tenth 102 for B.O.A.C., painted in a special Bristol colour-scheme (see p. 265). Bill Pegg, Bristol's chief test pilot, will carry out all the demonstration flights, which are to be made at the places shown in the accompanying map.

The U.S. and Canadian cities to be visited by the Britannia during its fortnight's demonstration tour of North America.

The airline companies to be visited are: Eastern, American, T.W.A., Western, Canadian Pacific, United, Continental, Capital and National (Capital have, of course, already seen the Britannia in England). The version of the Britannia which U.S. customers will be offered is the high-density 320, a medium-haul version of the long-haul 310 to which reference is made on p. 265. Mr. Masefield has stated that a delivery date of February 1958 can be offered to any new Britannia customer; this is nearly two years in advance of current Electra delivery dates (and six months ahead of first Electra production-deliveries) and some three years ahead of U.S.-built medium-jet rivals.

The interior of G-ANBJ, which *Flight* inspected before the aircraft departed, has been arranged to show examples of the various types of seating that the Britannia's voluminous interior makes possible. At the back, a series of special "luxury" seats is installed; amidships there is a lounge bar and vestibule; and forward are layouts of five-abreast and six-abreast seating.

The Britannia flew from London to Montreal against forecast headwinds of 50 kt in a flying time of 10 hr 52 min, arriving at Montreal at 0947 hr G.M.T. on Monday. An hour later—at 1055 hr—the aircraft was airborne again and heading for New York, where it arrived at 1155 hr. A non-stop trans-continental flight to San Diego was due to be made on Tuesday. Editorial comment: p. 239.

SEVEN TIMES TO THE SUN

ORDERS for turbine transports tend to overshadow the big business still being transacted for new piston-engined airliners. It is a remarkable fact that Douglas, for example, will still be delivering DC-6Bs two years hence, and that their backlog for DC-6s and DC-7s amounts to 294, worth £18m.

Last week, as an appropriate celebration of the first DC-6 decade (see last week's *Flight*), Douglas delivered their 700th aircraft in the series—a DC-7B for Eastern.

Not content with estimating how many times DC-6s and DC-7s have flown the "equivalent of round the world" (a current favourite statistic), Douglas point out that these aircraft have now amassed an aggregate mileage equivalent to seven trips to the sun.

FROM A CHINESE PILOT

THE story behind the opening of the world's highest airport, at Lhasa, capital of Tibet, appears to be one of quite remarkable achievement. We published a photograph in our July 20 issue of the first Chinese Il-12 to arrive at this 14,177ft airfield, and we have now received from Peking a first-hand account by the pilot, Pan Kuo-Ting, of the operation. Mr. Pan is a test pilot of the Chinese Civil Airlines Administration, with 12,000 hr in his log-book; he is a graduate of the Curtiss-Wright Aeronautical Institute in California.

Lhasa, it seems, was constructed in the almost unbelievably short time of one month by soldiers of the Chinese Army, working alongside Tibetan peasants and herdsmen. Facilities and equipment are still being added in anticipation of a regular eight-hour service to Peking. "Passengers will breakfast in our national capital," writes Mr. Pan, "and will arrive in Lhasa well before their evening meal, in good time to see the gold roofs of the Potala palace glinting in the setting sun."

His report is refreshingly free of political intrusion, and is a simple account of the inaugural flight, and of what the opening up of Lhasa will mean to Tibet and China. His mastery of the English language is considerable, as witness the following passage: "The rugged mountains gave way to the open expanse of the grass-lands of Northern Tibet. We flew low over a rolling green carpet broken by small lakes, dotted with the black tents of nomads and with thousands of yaks—the basis of Tibet's pastoral wealth."

PANAM PROTEST

THE tussle between PanAm and Northwest, described as "one of the hottest in the American airline industry," has arisen over the trans-Pacific route between the U.S. and the Far East. PanAm are reported to have said that they could cut trans-Pacific fares by as much as £35 if the Civil Aeronautics Board would grant them permission to fly by the great circle route in competition with Northwest instead of by the island-hopping service which is about 1,000 miles longer. PanAm argue that fares are being held at too high a level because there is no competition for Northwest over the shorter great circle route. If PanAm's submission is accepted by the C.A.B., the airline would—being the only trans-Pacific carrier serving California—be able to improve greatly the standard of service to Californian passengers bound for the Far East.

SORTING OUT CEYLON

AIRLINE operators in Ceylon (reports our correspondent in that country) comprising representatives of Air Ceylon, Air India International, Indian Airlines Corporation, B.O.A.C., T.W.A., K.L.M. and Qantas Airways, have asked to meet the Minister of Transport, Mr. Maitripala Senanayake.

Among the matters which they wish to take up with the Minister are the "total inadequacy" of the aircraft fire-fighting facilities at Ratmalana airport, the future of the major international civil airport—whether it is to continue to be at Ratmalana or Katunayake (see *Flight*, July 27) and the stoppage of work on the terminal building at Ratmalana.

"That's solved that one": Walter Gibb, Bristol's assistant chief test pilot, seen after bringing Britannia G-ANBH to Filton after the successful engine-icing investigations in Entebbe (see last week's issue of "Flight").

CIVIL AVIATION...

THE PRICE OF EXPANSION

CANADIAN PACIFIC AIRLINES' expansion programme, which should introduce five Britannia 310s (plus an option on five more) on to their routes within the next two years, will cost over £7m. Some of the money will be spent on a new hangar to house and service the aircraft, an overhaul bay in the existing hangar, and a new office building to act as an operational centre. Immediate equipment needs are to be met with Douglas DC-6Bs, a further six of which have recently been ordered. Two will be delivered this autumn and the remainder next year, to increase the total C.P.A. 6B fleet to 12.

A new C.P.A. service was inaugurated last week to Buenos Aires, and the polar-route service linking Vancouver and Amsterdam has now been increased to three flights a week.

BY AIR TO ROTTERDAM

ZESTIENHOVEN, Rotterdam's modern new airport, is now almost complete. With an eye to Air Charter's intention of ferrying motor cars from Southend, a "motel" will be built nearby, and a new company, "Rotterdam-Air," has been formed to handle the cars on the ground as well as all the airport's ground facilities. Channel Airways will operate two or three flights daily from Ipswich and, beginning in October, a once- or twice-daily service will be flown by Morton Air Services' 8-seat D.H. Doves. A point about the latter service is that a return ticket to Rotterdam will be valid on K.L.M. London-Amsterdam flights.

TALKING POINTS

EVERYBODY knows that sales of *Flight* approach their peak in August. All the ex-R.A.F. chaps of World War II, now middle-aged dads, packed with their families into holiday specials, settle back with *Flight* to an hour of jolting nostalgia. This article is for them; it will put them in the picture regarding some of the solemn problems confronting pilots today, and give them something to argue about with their sons.

Problem No. 1 will limber up their aeronautical brain muscles. Captain Tarnished (ex-216 boys will remember him as P/O. "Snowy" White, but that was years ago) is with a charter company. Taking off from Cigarro the other day he had a load of humming-birds. (They get their name, you remember, not because they're little stinkers, but because of the noise of their wings as they hover in flight, sucking nectar.) Now the aircraft was a little overweight for take-off.

"Not to worry," said Tarnished, "the total weight of our feathered friends themselves exceeds the amount that we are overweight. The critters get excited when we open up; when we reach the take-off point, they will all be hovering in flight. So their weight won't be on the aircraft at all."

"Nonsense," said his co-pilot. "I know they will all be hovering, but the reaction from their wings will be conveyed through the air on to the aircraft structure. So their weight will still be on the aircraft."

"Might be so if we were pressurized," admitted Tarnished. "But in this ship, with our open loading hatch, your argument doesn't arise."

Well, there's the problem. If humming-birds are beneath your dignity, you can make it helicopters in a Beverley. No prizes for the answer.

Now for a little physiology. If you are lying down at Newlyn (Liverpool for older chaps), and the air temperature and pressure happen to be 15 deg C and 1013.2 millibars, your height above mean sea level, your pressure altitude, and your density altitude are all zero. Remember? By varying only one of the three conditions, pressure, temperature, or height above sea level, you can change one of your three altitudes. Now suppose that at about 10,000ft people begin to suffer from lack of oxygen, and you had to frame legislation on the subject, which 10,000ft would you choose, actual physical altitude, or pressure altitude, or density altitude?

The existing law, the Air Navigation Regulations, has two sentences on the subject, and they are clear enough—even if one of them does consist of 388 words. And for non-pressurized aircraft it plumps for actual distance above the datum: "A height exceeding 10,000 feet . . . above M.S.L." Now wherever aircraft behaviour is considered, the A.N.R.s allow for the temperature, because of the difference in density, and it might seem strange that this is not allowed for with human beings. Let's pass on to pressurized aircraft; here the A.N.R.s take pressure altitude for the demarcation, namely, 700 mb. Now at that pressure in the Standard atmosphere the temperature is low. If we have a warm cabin, the density altitude inside it could be getting up towards 15,000ft; how does that affect the human body? Perhaps that question should be asked in the *British Medical Journal*. Let's get back to aeroplanes.

There were times when aircraft took off if the pilot thought that he and the machine were capable. For the benefit of those not in the civil flying picture today, I should explain that when Tarnished wishes to get airborne from that rather tricky airfield Teherobi he may have to satisfy himself by reference to the Flight Manual that he is not restricted on any of the following: Weight and temperature limitations; take-off run; emergency distance; take-off distance; or any of the first six segments of climb. This duty may take some time, for it involves calculations with the aircraft weight, airfield height, temperature, wind, nature and slope of the runway, the power available on various segments, and positions of flaps, undercarriage, etc. It might seem surprising that airfield height is used rather than pressure altitude, which might perhaps be 2,000ft different; but on temperature the A.N.R.s allow no cheating: unless the Minister has laid down otherwise, it must be the "temperature at the airfield at which the take-off is to be made." No consideration is given to the many circumstances which may affect pilot capability, nor to temperature inversion near the ground, nor humidity; but one must admittedly draw the line somewhere.

The only aspect you are being asked to consider now is "wind component opposite to the direction of take-off," an expression which recurs in a number of the regulations. That is the next question for you: the wind is 25 kt at right angles to the runway; what is the wind component along the runway? Now don't rush this one. Remember your simple triangle of velocities; wind velocity, track and groundspeed, course and airspeed. If you assume that you are airborne, with enough drift laid off to track along the runway, you will find that this "cross-wind" gives you a head-wind component "along the runway." But what about the moment before you are airborne, when your course and track are the same? You can't draw a triangle of velocities this time, but another feature arises. Because of the cross-wind you have to do something to give you differential drag to keep you straight. Whether it's coarse use of rudder, nosewheel steering, or differential throttle, it has lowered efficiency and so extended your take-off run. So it looks as though you have a tail-wind effect.

What is normally done in practice is to resolve the wind velocity into two directions, at right angles to, and parallel with the runway. Supposing the aircraft has a take-off speed of 80 kt, and the wind is 60 deg off the runway at 35 kt. We find that the wind component by triangle of velocities is 6½ kt more than by resolving; which should we use for calculating obstacle clearance? Before you dismiss it as of no importance, remember that after being factored the component has to be applied to no fewer than nine different aspects of the take-off performance.

A final question is for those of you who participate in your children's aeronautical activities, whether the reluctance is on your part or theirs. You may remember the regulations governing the flying of balloons and kites. Provided that your kite does not reach 200ft, and is not within three miles of an airfield, you need only comply with those regulations which refer to markings. But model aeroplanes may be more tricky; A.N.R.s define aeroplane as "a flying machine supported in flight by fixed wings." I don't want to worry you chaps, but have you read your regulations lately?

H. L. L.

"Flight" photograph

A new shape in U.S. skies: The Britannia 102 (actually B.O.A.C.'s tenth aircraft, G-ANBJ) seen on the eve of its departure for a fortnight's tour of North America (see report on p. 263). The colour-scheme is predominantly B.O.A.C.-blue, with maroon bars on the fin.

CIVIL AVIATION...

APARTHEID IN AIRLINERS

OVERSEAS airlines are so concerned at the application of apartheid on South African internal air services that several have asked their head offices to notify them by cable of any non-Europeans in passenger lists. South African Airways insist that if there is only one seat left on an aircraft it must remain unoccupied if the one adjoining is occupied by a non-European.

At Jan Smuts Airport recently, when an Indian from Durban arrived from Europe with his German doctor it was found there were only two seats left on the next day's aircraft. The clerk said he could not seat a non-European next to a European. When it was explained that the European was the other's doctor, the clerk agreed "reluctantly," our South African correspondent reports.

THE BRITANNIA 320

EMPHASIS is given to the Britannia 310's potential as a short- and medium-range airliner by the creation of the new type-number 320. There is no basic physical difference between the two versions, except for the provision of larger windows, but operationally the 320's payload-to-fuel ratio will be heavily weighted towards payload for short-range work. Maximum capacity, like the 310, is 28,000 lb and the Britannia's fuselage's high-density potential (up to 133 passengers can be accommodated) would be utilized to the full.

The 320 is undoubtedly the version being offered to American operators, and U.S. "domestic" features such as a carry-on luggage compartment and airstairs are standard 320 items.

Bristol claim that the 320 will be substantially more economic over ranges of 200 to 2,600 miles than any competitive airliner, and estimate for it a break-even load-factor over 200-mile sectors of less than 25 per cent. Cruising is a guaranteed 400 m.p.h.

AIR FRANCE IN 1955

AIR FRANCE'S annual report for 1955 was released in Paris last week. Sales increased by 12.4 per cent and total revenue rose to the equivalent of £52,000,000, the main increase being from passenger sales. Airmail receipts, however, dropped by 12.5 per cent compared with 1954, mainly due to the fact that airmail traffic between France and Indochina had fallen off.

Passenger mileage operated by Air France rose by 13 per cent, from 1,250,000,000 to 1,468,750,000 miles in 1955, in spite of the 50-day airport personnel strike during November and December 1955, and the average load factor remained fairly constant at 71 per cent. It is hoped to improve this over-high figure during 1956 and '57 with the introduction of a further four L.1049G Super Constellations and ten Lockheed L.1649A Super Star Constellations, which should improve the relationship between capacity offered and demand.

BREVITIES

LORD DOUGLAS will be chairman of I.A.T.A.'s annual general meeting in Edinburgh on September 17. Some 300 delegates from 60 airlines will be present.

* * *

The first S-58 helicopter went into service on August 4 with New York Airways.

* * *

C.A.A. have been lent a B-57 (Canberra) for tests on high-altitude air traffic control procedures.

* * *

S.A.S. has taken delivery of the first of its 14 DC-7Cs. The type will be introduced on the trans-polar route in October.

* * *

B.O.A.C. announce reduced one-way Atlantic fares for emigrants to the U.S.A. and Canada. Subject to Government approval they will be 60 per cent of the normal tourist rate.

* * *

B.E.A. are reported to have agreed that, when the Twin Pioneer is certificated, they will examine its possibilities on the Corporation's Scottish ambulance services.

* * *

In anticipation of the opening of the new airport at Rotterdam, a new company—"Rotterdam-Air"—has been formed to co-ordinate ground services and facilities.

* * *

Aquila Airways have obtained Government approval to cut the fare of their Solent flying-boat service from London to Madeira from £75 return to £54 return. The new rate (equivalent to about 4d. per mile) will come into effect on September 29.

* * *

An American trades-union leader, Mr. A. J. Hayes, says that the British industry has been allowed to "invade" the American market. "Certainly we want to see our allies-in-freedom develop their own basic defence and other industries . . . but not, it seems to me, at the expense of our research and productive capacities."

The American Export-Import Bank has granted a $6.2 million credit to Lockheed to finance the sale of four L.1649As to L.A.I.

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Air India's direct service to Australia, an extension of the present Bombay to Singapore route, is due to start in October.

* * *

The number of people killed in U.S. civil aircraft since 1927 totals 17,590.

* * *

A Tu-104 carried out a proving flight from Moscow to Peking on August 10.

* * *

Ex-King Michael of Rumania has obtained a C.A.A. commercial pilot's certificate. He works for the European subsidiary of Lear.

* * *

No serious casualties were suffered when a Britavia Hermes made a crash-landing (reportedly due to undercarriage collapse) at Karachi on August 5.

* * *

A bill to limit the power of the President to overrule C.A.B. actions in cases involving national defence or foreign policy has been passed by the U.S. Senate.

* * *

Explaining the reasons for India's purchase of Il-12s, the Minister of Communications, Mr. Jagjivan Ram, said: "We require a medium-type aircraft like the Dakota and no suitable aircraft of this type except the Ilyushin has been designed in the world."

* * *

The Jamaican Government estimates the cost of improving Palisadoes airport for jet services at £2,680,000. Dredging has been completed and the work of filling and paving the runways is being undertaken by the British firm of John Mowlem and Company.

* * *

The Institute of Aeronautical Sciences was due to conclude today (August 17) its annual National Turbine-Powered Air Transportation meeting at San Diego. Due to be addressed by Mr. Peter Masefield (see p. 263), the meeting was to be attended by about 600, and the topics to be discussed were: (1) the introduction of turbine airliners into service, (2) turbine airliner noise, (3) design and testing, (4) the future of "mass air transportation."

A rival for the Heron: First flight of the Cessna 620, seen here at Wichita doing its taxying trials, was imminent as we went to press. Aimed at the executive market, it is pressurized and can carry up to 18 passengers. Engines are 320 h.p. Continental GS0526-As.

The two-year-old Comet 3, now being made representative in all essentials—RA.29 engines, systems and aerodynamics—of the Comet 4. Detachable wing-tip panels will be fitted to enable a check on 4A performance to be made. Because of this heavy shop-programme, the Comet 3 will not be at the S.B.A.C. Show next month.

"Flight" photograph

THE COMET in AMERICA

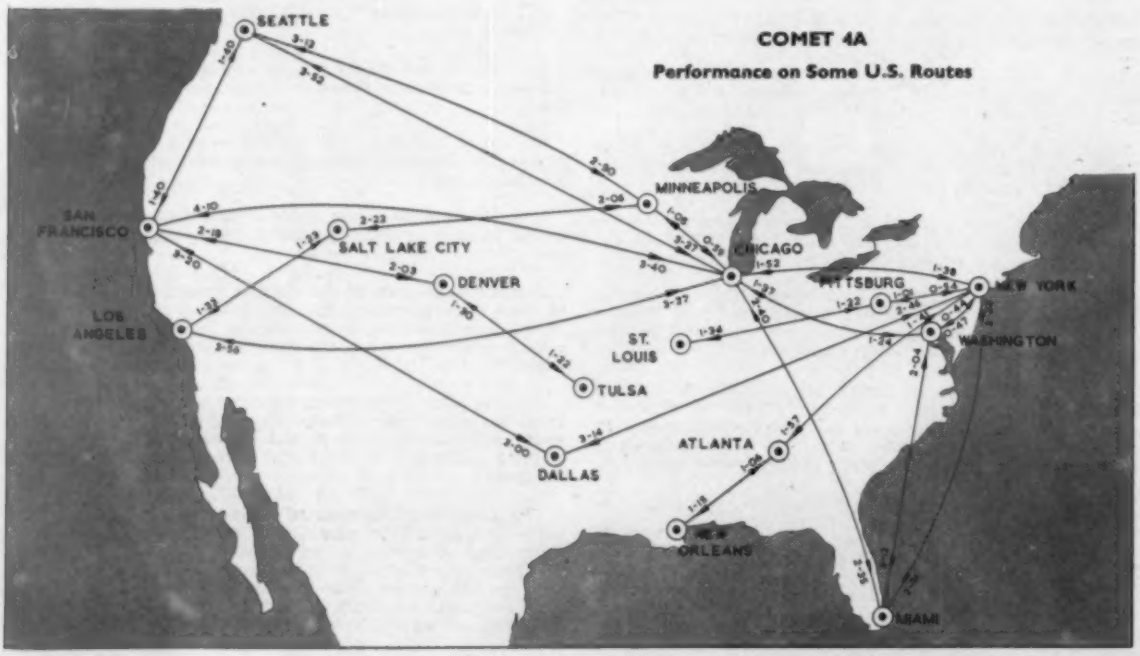
The 4A's Performance Brought to Life on U.S. Routes

IT is difficult for Europeans to comprehend the full impact on Americans of airline schedules such as Chicago to Los Angeles in four hours, or Dallas to San Francisco in 3½ hours. In a country where the tempo of life seems a natural match for the pace of the jet, such schedules—which are typical of those offered by the Comet—promise big business for the airlines with jets.

Eight of the twelve major U.S. carriers ordered 707s or DC-8s (Table 1). Of these, however, five also ordered turboprop Electras to beat the Viscount, introduced by Capital, at its own game on the medium-haul routes where the speed-margin between jet and turboprop is small and where the turboprop's superior economy is the greatest consideration.

It seemed for a time that the U.S. air transport industry's favourite guessing game "Jet or Turboprop" had ended with jets chosen for the long hauls and turboprops for the medium and short stages. Then the medium jet, under Convair and Douglas sponsorship, began to intrude into the turboprop's territory. The invasion was resisted; profit-margins in the U.S. industry are no greater than in air transport elsewhere, and there was no rush to buy aircraft which would be more costly to run and which would not offer significantly shorter block-times than the 400-m.p.h. turboprops.

When the Golden Arrow came on the market there were four carriers still uncommitted to medium-haul equipment (excepting Northeast and Northwest, both of whom seem to be showing little inclination to move into the turbine age). These four were T.W.A., Delta, Capital and United. T.W.A. and Delta decided to order 40 Golden Arrows between them; Capital bought four



This map provides a selection of U.S. routes to give a general picture of the Comet 4A's capabilities. All these stages can be flown with the 22,690 lb tourist payload. The figures show the appropriate block times (hr/min) in mean wind conditions and including 15 min terminal time. Detailed Comet 4A capabilities over ten U.S. routes are provided in Table 3 opposite.

TABLE 1

TURBINE ORDER BOOK OF 12 MAIN U.S. DOMESTIC AIRLINES
August 13, 1956

	Long-haul Jets		Medium-haul Jets		Medium-haul Turboprops	
	707	DC-8	Golden Arrow	Comet	Electra	Viscount
American ...	30				35	
Braniff	5				9	
Capital ...				14		75
Continental ...	4					15
Delta		6	10			
Eastern ...		18			40	
National ...		6			23	
Northeast ...						
Northwest ...						
T.W.A. ...	27*		30			
United ...		30				
Western ...					9	

*Of which 9 are of the domestic (120) version.

Comet 4s and ten 4As; while United—who last spring had, with T.W.A., been about to buy Electras—continued to waver.

Although T.W.A.'s and Delta's decision caused the turboprop airlines to look to their medium-haul defences, there was no rush to buy medium-jets. But, it might be asked, will Capital's purchase of the Comet—with its attractions of early delivery, experience, favourable contract-terms, etc.—have a more pronounced effect?

Perhaps an answer to this fascinating question, which airlines in Europe and elsewhere as well as in the U.S.A. are asking, may become apparent very soon. If we examine the order-books of the U.S. airlines (Table 1), we see that, excluding Northeast and Northwest, United is the only operator still to make up its medium-haul mind. If it orders jets—and we can be sure that D.H., Douglas and Convair are all in very close touch with Mr. Patterson—this could not be taken as a sign of any significant general trend toward medium-jets. It would, however, be more significant were they to choose turboprops, and no doubt Bristol, who are at this moment demonstrating a Britannia in the U.S., are keenly aware of this.

But especially worthy of attention are American, Eastern, National, Western and Braniff. All five have settled for the Electra, but they could all be said to be "threatened" by Capital, T.W.A. and Delta medium-jet competition—two of them, American and Eastern, particularly by Capital's Comets, which will be in service at about the same time as the Electra. Capital competes with American—its first rival—on the strong trade-routes in and out of New York to Washington, Chicago, Detroit and Pittsburg, and between Washington and Chicago. American might bide their time until delivery of their first 707-120s, even though the above routes (averaging about 600 miles) are really too short for the essentially coast-to-coast 707. According to the Boeing and American programme, the first 707 will be with American only six months after delivery of Capital's first Comet 4, the first American 707 service being scheduled for June 15, 1959 (Capital's first Comet service, between Washington and Chicago, is scheduled for January 1, 1959). So far as competition with T.W.A. and Delta is concerned, American have to look to a possible Golden Arrow challenge (albeit later than the Comet's) on routes into and out of New York, i.e. to Washington, Chicago, Detroit and Pittsburg, as well as from New York to Tulsa and Houston, Chicago to San Francisco, Washington to Houston and Tulsa to Los Angeles. These last three routes, in length between 1,300 and 1,900 miles, will probably be handled by the big jets anyway, so that the question of medium-jet competition may not arise. It is thus on the rich northern routes into and out of New York that American seem faced with a medium-jet (particularly Comet 4) challenge, and any American move to buy medium jets would, it appears—in view of their large stock of Electras—be most significant.

How about Eastern? They will, it may be assumed, be pitting Electras against Capital's Comets on such routes to the south as New York and Washington to Atlanta and New Orleans as well as on the hotly contested New York to Washington run. They could, as American might, wait until they could put their big jets (DC-8s) on the southern routes, bearing in mind that Capital will probably concentrate their Comets on the northern routes at first. The Comet may perhaps not prove as much a challenge to Eastern as it might to American—except on the New York to Washington run—though Eastern may well be worried if Capital, under the Capital-National interchange, put Comets on to Eastern's prized Washington to Miami route.

So far as T.W.A. and Delta Golden Arrow competition is concerned, Eastern may have to look in addition to such sectors as Washington and New York to Houston. The latter, however, are longer hauls which may be primarily fought out by the big jets. It would, it seems, be even more significant if Eastern were to buy medium-jets than if American were to do so.

However, National, Western and Braniff are especially worthy of attention when trying to assess what orders from whom would amount to a swing in favour of the jet for medium-hauls. Although National operate interchange services with Capital between Washington and Miami, they may have to compete with Comets on the New York to Philadelphia and Washington routes. T.W.A. or Delta Golden Arrow competition may be felt on these routes also; but National's main service is to the south, for which route

TABLE 2

Aerodromes	Runway length (ft)	Altitude (ft)	Temp. (deg C)	Maximum Permissible Take-off wt (lb)	Maximum Permissible Landing wt (lb)
Atlanta ;	7,860	1,024	30	152,000	113,000
Chicago (O'Hare)	8,000	657	27	152,500	113,000
Dallas	7,750	483	32	152,500	113,000
Denver	10,050	5,331	29	145,500	113,000
Los Angeles ...	8,560	125	28	152,500	113,000
Miami	9,400	S.L.	31	152,500	113,000
Minneapolis ...	6,500	840	27	140,500	105,500
New Orleans ...	7,000	S.L.	31	148,000	113,000
New York (Idlewild)	9,420	S.L.	28	152,500	113,000
Pittsburgh ...	7,500	1,168	27	149,400	113,000
St. Louis	10,015	558	32	152,500	113,000
Salt Lake City ...	8,300	4,220	33	136,500	113,000
San Francisco ...	8,870	S.L.	21	152,500	113,000
Seattle	8,500	416	23	152,500	113,000
Tulsa	10,000	674	32	152,500	113,000
Washington ...	6,740	S.L.	30	146,000	113,000

TABLE 3

	N' York to Chicago	Chicago to Los Angs.	Chicago to S. Fr'isco.	N' York to Dallas	Dallas to S. Fr'isco.	Wsh'ton to Chicago	N' York to Pittsburgh	Chicago to Minn.	N' York to Miami	N' York to Wsh'ton
Sector distance, st. miles	730	1,746	1,863	1,380	1,474	600	319	350	1,091	213
Diversion aerodrome	Detroit	Fresno	Fresno	Houston	Fresno	Detroit	Washington	Milwaukee	Tampa	Philadelphia
Diversion distance, st. miles	220	202	170	240	170	220	180	300	205	130
Operation against "85 per cent Annual Wind"										
85 per cent sector wind (-ve = head wind) m.p.h.	-72	-54	-54	-77	-53	-72	-76	-49	-52	-77
Diversion wind (-ve = headwind) m.p.h.										
Maximum permissible take-off weight lb	152,500	152,500	152,500	152,500	152,500	146,000	152,500	152,500	152,500	152,500
Maximum permissible landing weight lb	113,000	113,000	113,000	113,000	113,000	113,000	113,000	105,500	113,000	113,000
Take-off weight required lb	125,600	151,500	152,500	143,900	143,500	122,400	114,100	116,700	134,100	110,300
Landing weight required lb	104,200	105,000	104,400	105,000	104,000	104,000	103,000	105,200	104,300	101,900
Payload (limited by capacity) lb	19,100	19,100	19,100	19,100	19,100	19,100	19,100	19,100	19,100	19,100
Fuel on arrival over destination lb	12,900	13,700	13,100	14,000	12,700	12,800	11,700	13,900	13,000	10,600
Cruising altitude ft	23,500	23,500	24,600	23,500	23,500	23,500	23,500	23,500	23,500	23,500
Cruising speed m.p.h.-t.a.s.	533	533	533	533	533	533	533	533	533	533
Operation against "50 per cent Annual Wind" with 70 per cent Capacity Payload (13,350 lb)										
50 per cent sector wind (-ve = headwind) m.p.h.	-49	-39	-39	48	-33	-49	-47	-36	-35	-48
Take-off weight required lb	118,500	143,200	145,800	135,300	135,200	115,100	107,400	110,200	125,900	103,800
Total fuel load before starting engines lb	32,400	57,100	59,700	49,200	49,100	29,000	21,300	24,100	39,800	17,700
Total fuel consumed lb	21,400	45,400	48,400	37,200	38,300	18,200	11,500	12,100	28,800	8,900
Block time, I.S.A. + 10 deg C. hr-min	1-52	3-56	4-16	3-14	3-20	1-37	1-01	1-05	2-31	0-47
Block speed m.p.h.	391	444	447	426	443	371	314	323	434	272

This table provides details of the Comet 4A's capabilities over ten U.S. routes. Two calculations have been made: (1) for 85 per cent frequency winds, representing severe conditions. Take-off weights to carry the first-class capacity payload of 19,100 lb are shown together with the maximum take-off weights allowable from airfield range considerations; (2) block fuel, block time, block speed and total fuel for mean-annual-wind conditions assuming that 70 per cent of the capacity payload is carried. These figures therefore show the performance to be expected from the Comet 4 on a year-round basis.

COMET IN AMERICA . . .

it may be presumed their six DC-8s are intended. It would be surprising if National do not, with a strong Electra fleet on order, strongly resist a purchase of medium jets.

Western will not be affected by Capital Comet competition and possibly not at all by T.W.A. or Delta Golden Arrow services (except perhaps Denver—San Francisco) and they might not appear to be likely purchasers of medium-jets.

Braniff may be operating Electras against Comets from New York and Memphis to Washington; and they may be up against Golden Arrows operated by T.W.A. between Chicago and Kansas City. Not, one might suppose, sufficient justification for a Braniff switch to medium-jets.

It seems that the airlines most likely to be worried about Comet 4 or Golden Arrow competition are American and Eastern. Both have banked heavily on the Electra and it might be concluded that, were these two airlines to order medium jets from D.H., Convair or even Douglas, a significant swing towards jets on medium-haul routes was taking place. Especially, it might be added, as each has big jets to deploy, if the competitive need arises, on the medium routes.

National, Western and Braniff may, it appears, be least worried by medium-jet competition. It can therefore be argued that it would be even more indicative of a swing towards medium jets were any of these to sign up with Convair, D.H. or Douglas. An order for Comets, Golden Arrows or DC-9s from any of these three Electra airlines might be most significant of all, since it would be placed relatively free of competitive pressures.

Continental, so far not considered, may be up against jet competition (including T.W.A. Golden Arrows) on such routes as Chicago to Denver and Kansas City and from Kansas City and Denver to Los Angeles. They may consider that such routes may be competitively handled by the small fleet of 707s which they have on order, and that the 15-strong fleet of Viscount 810s (which may be soon increased to 20) will satisfactorily take care of the rest of their network. They do not appear to be unduly pressed to buy medium jets, and being one of the comparatively small U.S. carriers, they may resist the addition of medium jets to their fleet: on the other hand, Mr. Six's airline is notably progressive, and has plans before the C.A.B. for expansion of its western routes. A Continental order for medium jets might, it seems, be significant, since they would not be forced into so doing by competitive considerations. Yet they may well "do a Comet" on their competitors just as Capital have done, in the same way that—although not competing with Capital—they bought the Viscount.

The airlines to watch then are those with turboprop fleets on order who are not unduly pressed by the challenge of Capital, T.W.A. and Delta medium-jet competition. These are National, Western, Braniff and Continental. Of these all but Western have big jets to line up against Comets and Golden Arrows if need be, so that National, Braniff and Continental are to be watched closest of all. And it may be concluded that the best indication of strong resistance *against* a swing to medium jets would be if American and Eastern—who could be said to be threatened most of all by Comets and Golden Arrows (particularly Comets)—do *not* consider medium jets worth buying.

Although the foregoing remarks are necessarily based on surmise, one plain fact can be considered. This is that, notwithstanding the competitive *pros* and *cons* of jet or turboprop for medium-haul operations, of the three jets just mentioned the Comet 4A is the most realistic challenge. The word "realistic" is carefully chosen, after consideration of the facts. These are that, compared with the Golden Arrow and the DC-9, the Comet's delivery date of mid-1959 (or late 1958 if "interim" Comet 4s are ordered) is earlier, and behind the aircraft are experience and factory-capacity that dispel any doubts that D.H. are allowing too little margin for development or production delays. Secondly, the reputation and experience of Rolls-Royce are strongly in favour of the aircraft. Further, the terms of any U.S. contract for British equipment, if the Capital orders for Viscounts and Comets are any guide, are extremely favourable. And, it might be added, so are the offers of technical service, as might be expected of firms trying to establish themselves in a new and highly competitive market. Finally, as the accompanying tables show, the aircraft makes sound sense on U.S. routes. It fits easily into the networks of the U.S. operators (with the exception of the non-stop coast-to-coast service, for which the aircraft is not intended) and offers a payload-speed performance which, from the provisional Convair and Douglas figures so far published (see Flight, July 6) compares within a few pounds and a few minutes with the Golden Arrow and DC-9. The operating cost (see Comet 4A A.T.A. curve in *Flight* of July 27) shows that a 50 per cent break-even load factor is attainable on stages of about 600 miles (about the average length of the whole U.S. airline network) a figure which—although not as good as may be achieved by the projected turboprops—still leaves a big profit margin. Actual direct costs per seat-mile (neglecting freight revenues) for the tourist version work out at 1.95 cents over 500 miles and 1.62 cents over 1,500 miles. And the payload of about 19,000 lb (22,690 lb tourist) is not so large for medium-stage work that high frequency of service—the cost-reducing factor which generates the traffic in the short- and medium-haul markets—cannot be maintained at high load factors.

The Comet's "airport behaviour," as may be seen from Table 2, enables it to operate into and out of the major U.S. airports as they exist today, and the aircraft's wheel-loadings are well within the bearing capacity of the major-airport pavements. Climb performance after take-off is such that the 152,500-lb gross weight is only limited at airfields above 7,000ft: this consideration can therefore be dismissed for U.S. domestic operation.

A selection of ten routes is presented in Table 3, varying in length from about 200 miles to 2,000 miles, to demonstrate the capabilities of the aircraft in U.S.-operation. Other routes (see map), which could not be included for space reasons, are, like those shown in Table 3, also well within the Comet's capabilities. In one case only (Chicago - San Francisco) is it necessary to fly above the maximum-speed height (see *Flight*, July 27) of 23,500ft. Table 3 illustrates capabilities of the 70-seat first-class aircraft (the version which Capital will be using), but the 92-seat tourist aircraft is able to operate all the routes with equal facility, with the one possible exception of sectors into Minneapolis, an airport where rather too low a maximum permissible landing weight (105,500 lb) would have to be used.

Table 3 is calculated according to the high-speed operating procedure (*Flight*, July 27) but the aircraft can of course be operated like the Comet 4 according to higher altitude long-range techniques. An illustration of the "rate of exchange" between cruising altitude and payload range may be obtained from the following example. Cruising at 30,000ft instead of at 23,500 gives about 8,000 lb more payload over the same range, or alternatively 400 miles more range with the same payload, while cruising true air speed is only reduced by 17 m.p.h.

Such are the Comet 4A's formidable capabilities. It may be assumed that, if in the next few months the fickle pendulum does begin to swing toward the jet for medium stages (in Europe and elsewhere as well as the U.S.), it may well have been these capabilities which helped to send it on its way. J.M.R.

GRAND PRIX DE FRANCE

THE French Aero Club is organizing a light aircraft competition lasting from September 7 to 11 and intended to show up the aircraft with the best qualities of design and performance. Handicap formulæ take into account loading, passengers, equipment and such factors as visibility from the cockpit. There will be a speed trial over the 234 km from Biarritz to Toulouse/Blagnac and take-off and landing tests respectively over one-metre and three-metre markers. Detailed assessments and regulations have been prepared including, for example, the attachment of accelerometers to the aircraft for the landing trials, so that landing distance can be modified in relation to the abruptness of the touch-down. A figure of over 4g will disqualify the competitor.

Immediately after the Grand Prix de France there will be a competition for the Coupe Touristique of the French Aero Club, open only to those who have taken part successfully in the Grand Prix. Tests will include arriving precisely at a declared E.T.A. at Carcassonne, a navigation trial between Carcassonne and Cannes, and a *concours d'élégance* to be held at the latter airfield. The navigation leg will include maintaining 85 per cent of the speed shown in the previous speed trial and passing at precise times over two check points which will be nominated in sealed orders delivered just before take-off. The *concours d'élégance* will include assessment of the *élégance* of pilot, passengers and their baggage. The competitions as a whole should strongly favour the skilled pilot and the really useful touring aircraft.

The Grand Prix is to be held for three consecutive years and many prizes of up to £500 are being offered. Entry should be effected through national aero-clubs.

FORTHCOMING EVENTS

Aug. 17-19. Sportsflyveklubben: International Rally, Denmark.
Aug. 25-26. Midland Aero Club: International Rally, Elmdon, Birmingham.
Sept. 3-9. S.B.A.C. Display, Farnborough ("Public" days, 7th, 8th, 9th).
Sept. 7-12. French Grand Prix, France.
Sept. 8. R.A.F. Station Silloth: At Home.
Sept. 10-16. Battle of Britain Week.
Sept. 15. Battle of Britain Day.
Sept. 16. All Britain Model Aircraft Rally, Radlett.
Sept. 18-23. Aero Club of Italy: International Air Week.
Sept. 19-21. R.Ae.S. and Institute of Physics: Joint Conference, Cranfield.
Sept. 27-28. Aerodrome Owners Association: Annual Conference, Southampton.

This unusual low-altitude photograph of the Lee-on-Solent control tower, with one of the crowded car parks beyond, was taken by a "Flight" photographer from the veteran Swordfish (piloted by Lt-Cdr. Rudorf) which led the fly-past at the Air Day reported below.

SERVICE AVIATION

Royal Air Force and Fleet Air Arm News

Lee-on-Solent Air Day

LAST Saturday, in weather that turned out to be a great deal better than the forecasts suggested, H.M.S. *Dædalus* (R.N. Air Station Lee-on-Solent) held its annual Air Day and At Home, attracting the usual big crowd. Since last year's event the station (which accommodates the headquarters of the Fleet Air Arm) has seen several major changes, several of them a result of the closing of H.M.S. *Siskin* (R.N.A.S. Gosport). Much of the specialist training previously conducted at Gosport is now at Lee, and the helicopter units have also moved across. These include No. 705 Sqn. (Lt-Cdr. G. C. J. Knight), which trains aircrew, and—when it is not embarked in a carrier—No. 845 (Lt-Cdr. J. Jacob), the Navy's first anti-submarine helicopter squadron.

H.M.S. *Dædalus* continues to operate a communications squadron, No. 781 (Lt-Cdr. M. W. Rudorf), equipped with Sea Devons, and also maintains the four-week Junior Officers' Air Course, giving sub-lieutenants air experience in Vampire Trainers, Balliols and Sea Princes. Another of the station's varied duties is the flight testing of Sea Hawks after overhaul at the R.N. Air Yard, Fleetlands.

Though the Air Day programme contained some "star turns" familiar both here and at other displays—notably the masterly aerobatics of the Sea Hawk quartette from No. 800 Sqn. at Brawdy (leader, Lt-Cdr. J. D. Russell) and the superb Sea Hawk evolutions of Lt-Cdr. D. P. W. Kelly—the accent was on helicopters. Thus nine Dragonflies and six Whirlwinds took part in the fly-past, their pilots valiantly maintaining a close and low formation in a gusty 40-knot wind; four Whirlwinds of No. 845 Sqn. performed an effective ballet; rescues were demonstrated; a damsel was snatched from the top of a genuine hay-cart which was itself being towed along at a very fair rate by a Whirlwind with minesweeping gear; a "Mrs. Spreadbury" (who appeared to be some relative of Lt-Cdr. E. C. Spreadbury of No. 705 Sqn.) made off with a Hiller in which she had been promised a joy-ride; and the whole helicopter strength—as well as assorted jet aircraft—took part in an elaborate setpiece concerned with the suppression of a villainous-looking bandit force led by one Mustapha Kanal. The really outstanding helicopter item, however, was the appearance—not unexpected, for it was mentioned in the printed programme—of the Sikorsky S-58, reference to which is made on page 241 of this issue.

A brief but spectacular fixed-wing contribution was provided by the D.H.110, brought over by Jock Elliott. He made a slow pass with "everything down," and a fast pass with the two Avons trailing black smoke; then he came back rolling the big, formidable-looking aircraft at fairly low altitude, and finally made his exit with the "barn-door" air brake under the fuselage lowered.

Lee-on-Solent makes its flying display a compact, precisely timed affair (two sections of 45 and 30 minutes each, divided by a tea interval), leaving visitors plenty of time to inspect the excellent aircraft and other static show exhibits without feeling they are missing anything. The idea seems an admirable one.

The Cup that Cheers

A SILVER cup has been presented to the formation aerobatic team of No. 43 Sqn.—by Gen. S. A. Raffaelli, Chief of the Italian Air Staff—in recognition of their fine performance during the air display at Fiumicino airport, Rome, in June.

At Turnhouse, the unit's temporary base, Col. G. Pelosi, the Italian Air Attaché in London, made the presentation to the C.O. (Maj. R. O. Roberts, U.S.A.F.) on Wednesday of last week.

Seen at Lee: a Whirlwind (above) fitted with what appears to be an arrester hook—actually it is minesweeping gear.

"Flight" photographs

Close-up of one of the new "Mk 3" Whirlwind tails, designed to give more main-rotor clearance in gusts and—by means of the deeper tail-rotor arm—improved longitudinal stability. The two fins are now horizontal.

Senior Appointments

IT is announced that A.V-M. W. J. Crisham is to be A.O.C. Air Headquarters Levant from this month.

A.V-M. Crisham has been A.O.C. No. 12 Group since 1953 and was before that Commandant of Central Fighter Establishment. He has been associated with fighter operations during the major part of his service and led No. 23 Sqn. on night intruder work during the war. After that he commanded the fighter sectors of Kirton-in-Lindsey and Tangmere, the latter during the invasion of Normandy. After the war he commanded R.A.F. Oakington and was C.I.O. at H.Q. M.E.A.F.

A.V-M. W. A. Opie is to be A.O.C. No. 41 Group with effect from next month. He has most recently been Principal Director, Research and Development (Aircraft) at M.o.S. He was appointed Director of Servicing Research and Development at M.o.S. in 1952 and became Assistant Controller of Supplies (Air) in 1953. He was

SERVICE AVIATION . . .

commissioned from Cranwell in 1922 and commanded No. 18 Sqn. in France in 1939.

G/C. A. Pyke is to command R.A.F. Winthorpe, Notts. He joined the Electrical and Wireless School, Flowerdown, in 1927 and graduated from Cranwell. He served with Nos. 16 and 20 Sqns. and joined Maintenance Command H.Q. in 1941. Since then he has held technical appointments, and has taken R.A.F. and Joint Services' Staff College courses.

Royal Air Force Appointments

THE following continues a list of Royal Air Force appointments issued periodically by the Air Ministry:—

G/C. R. P. Cauthery to H.Q., Maintenance Command, for air staff duties; G/C. P. S. Dundas, O.B.E., for duty as the R.A.F. member of the N.A.A.F.I. Board; G/C. D. H. M. Graham, O.B.E., to H.Q., Home Command, for administrative staff duties; G/C. E. J. Smith to R.A.F. Honington, to command; G/C. R. G. Bowditch, C.B.E., to No. 32 M.U., to command; G/C. H. A. Sudbury to H.Q., Maintenance Command, for administrative staff duties; G/C. D. W. Williams, O.B.E., to H.Q., 2nd Tactical Air Force, for technical staff duties; G/C. G. M. Gillan to H.Q., Far East Air Force, for air staff duties; G/C. G. H. H. Proctor, C.B.E., to R.A.F. Weeton, to command; G/C. B. W. S. Smith to H.Q., Far East Air Force, for administrative staff duties.

W/C. D. J. Barber to Air Ministry, for duty in the Department of the Air Member for Supply and Organisation; W/C. H. J. R. Hailstone, O.B.E., to H.Q., Middle East Air Force, for technical staff duties; W/C. S. J. H. Carr, D.F.C., to R.A.F. Uxbridge, for administrative duties; W/C. J. B. Denning to H.Q., Flying Training Command, for administrative staff duties; W/C. B. R. W. Forster, D.F.C., A.F.C., to Air Ministry, for duty in the Department of the Air Member for Supply and Organisation; W/C. C. W. J. Cozens to R.A.F. Ahlhorn, for technical duties; W/C. A. S. C. Jukes to H.Q., Fighter Command, for technical staff duties; W/C. D. A. Reddick, O.B.E., D.F.C., A.F.C., to R.A.F. Hereford, for administrative duties; W/C. J. H. Sindall, D.S.O., to R.A.F. Melksham, for administrative duties; W/C. A. H. Simmonds, D.F.C., to H.Q., 63 Group, for administrative duties; W/C. T. Willcox to H.Q., Far East Air Force, for administrative staff duties; W/C. J. P. M. Woolley to H.Q., Middle East Air Force, for administrative staff duties; Wg/O. C. E. Warren, W.R.A.F., to H.Q., Far East Air Force, for administrative staff duties; W/C. C. S. Harley, to H.Q., 2nd Tactical Air Force, for administrative staff duties (with the acting rank of group captain); W/C. F. G. Carle, O.B.E., to No. 115 Maintenance Unit, Habbaniya, to command; W/C. N. A. Gwyther, O.B.E., to H.Q., No. 41 Group, for technical staff duties; W/C. W. O. Jones, to No. 1 (L.A.A.) Wing, to command; W/C. J. E. Preston to R.A.F. St. Eval, for flying duties.

W/C. G. F. Lerwill, D.F.C., to R.A.F. Kirton-in-Lindsey, to command (with the acting rank of group captain); W/C. H. A. S. Disney, O.B.E., to R.A.F. Uxbridge, as staff officer (air) to the Inspector General; W/C. C. J. Fox, M.B.E., to Air Ministry, for duty in the Department of the Air Member for Supply and Organisation; W/C. P. M. Gosse, M.C., to H.Q., No. 83 Group, for air staff duties; W/C. H. R. Johns to H.Q., Maintenance Command, for administrative staff duties; W/C. V. H. A. McBratney, A.F.C., to R.A.F. St. Mawgan, for flying duties; W/C. A. Miller to H.Q., Bomber Command, for administrative staff duties; W/C. D. L. Norris-Smith, O.B.E., to R.A.F. Bawdsey, to command; W/C. S. V. Perry, C.B.E., to Air Ministry, for duty in the Department of the Air Member for Supply and Organisation; W/C. I. R. Campbell, A.F.C., to H.Q., Northern Sector, for air staff duties; W/C. J. B. Evans to R.A.F. Nicosia, for technical duties; W/C. C. N. Foxley Norris, D.S.O., O.B.E., to R.A.F. West Malling, for flying duties; W/C. J. H. Nancarrow to Air Ministry, for duty in the Department of the Air Member for Supply and Organisation; W/C. R. W. Pye to Air Ministry, for duty in the Department of the Chief of the Air Staff; W/C. H. H. Wood-Glover, M.B.E., to No. 95 (L.A.A.) Wing, to command; W/C. D. G. Perry to H.Q., Middle East Air Force, for technical staff duties; W/C. J. T. O'Sullivan to H.Q., No. 2 Group, for air staff duties (retaining acting rank of wing commander).

S/L. F. C. Austin to H.Q., No. 41 Group, for technical staff duties (with the acting rank of wing commander); S/L. M. L. L. Bathe to H.Q., No. 12 Group, for air staff duties (with the acting rank of wing commander); S/L. R. J. Bartlett to H.Q., Maintenance Command, for technical staff duties (with acting rank of wing commander); S/L. G. W. Buckland, D.F.C., to H.Q., Transport Command, for air staff duties (with acting rank of wing commander); S/L. A. G. Cadman to Air Ministry Unit, Ruislip, for administrative duties (with acting rank of wing commander); S/L. R. L. S. Coulson to H.Q., Middle East Air Force, for air staff duties (with acting rank of wing commander); S/L. J. Midwood to R.A.F. Abingdon, for administrative duties (with acting rank of wing commander); S/L. K. W. Laurence to Air Ministry, for duty in the Department of the Air Member for Supply and Organisation (with the acting rank of wing commander); S/L. A. Mackelden to No. 8 School of Technical Training, for technical duties (with the acting rank of wing commander); S/L. Ben Brown to R.A.F. South Cerney, for technical duties (with the acting rank of wing commander); S/L. D. H. Keary to H.Q., 3rd United States Air Force, Ruislip, for liaison duties (with the acting rank of wing commander); S/L. W. S. C. Watkins to H.Q., 22 Group, for administrative staff duties (with the acting rank of wing commander).

Members of the mountain rescue team from R.A.F. Station Valley bringing a "shipwreck survivor" up the cliffs during an exercise held between the North and South Stack, Anglesey, Wales.

Pilot's eye view of the carrier "Bulwark" as she left Portsmouth for the Mediterranean last week. She embarked an air group in the Channel. The training carrier "Theseus" also sailed, but carried a contingent of troops.

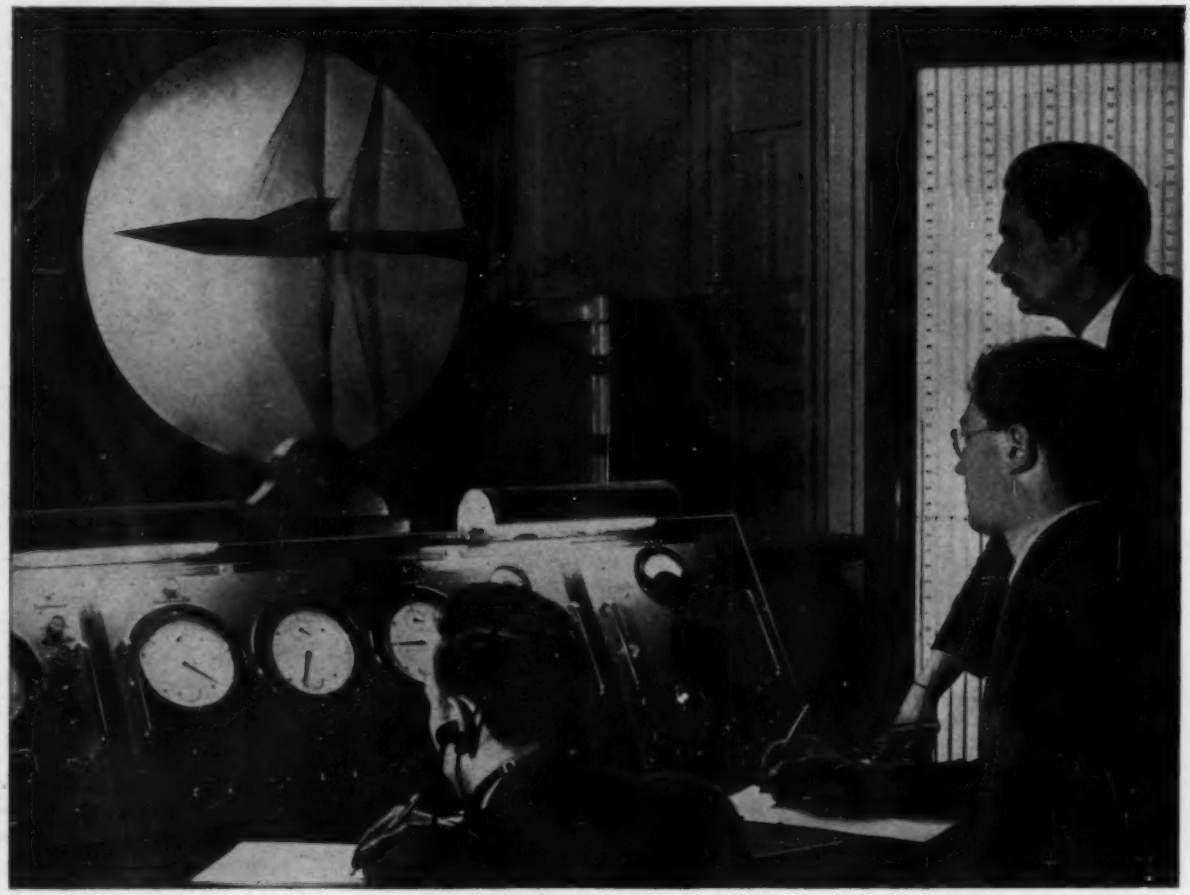
Squadron History

INFORMATION and photographs concerning the history of No. 805 Sqn. R.A.N., are being sought by Staff Officer, No. 805 Sqn., R.A.N., R.A.N.A.S., Nowra, 6C, New South Wales, Australia. Material supplied will, it is stated, be carefully treated and returned if requested.

Reunions

THE third reunion of the R.F.C. and R.N.A.S. will be held in London on August 31. Tickets (40s) from G/C. C. S. Morice, 10/12 King Street, London, S.W.1 (Whitehall 3131).

The North Coates Wing reunion dinner is to be held in London on October 20. All ex-members of Nos. 143, 236 and 254 Sqns. are eligible. Details from F/L. H. L. Karby, M.B.E., 73, Lake Rise, Gidea Park, Essex, or by telephone from Mayfair 8800.



Tunnelling for facts

The aircraft designer's most powerful weapon is still the wind-tunnel, though not quite the same sort of wind-tunnel that was good enough before Professor Mach made his name. If you are in the business of making supersonic aircraft, you must have a supersonic wind-tunnel—or more precisely a supersonic tunnel that is also usable at transonic speeds, for it is just below and just above the speed of sound that really funny things happen to the air-flow round an aeroplane. To build such a tunnel poses two problems—how to move a vast quantity of air fast enough, and how to stop shock waves choking the tunnel at high subsonic speeds so that testing becomes unreliable at and near the speed of sound.

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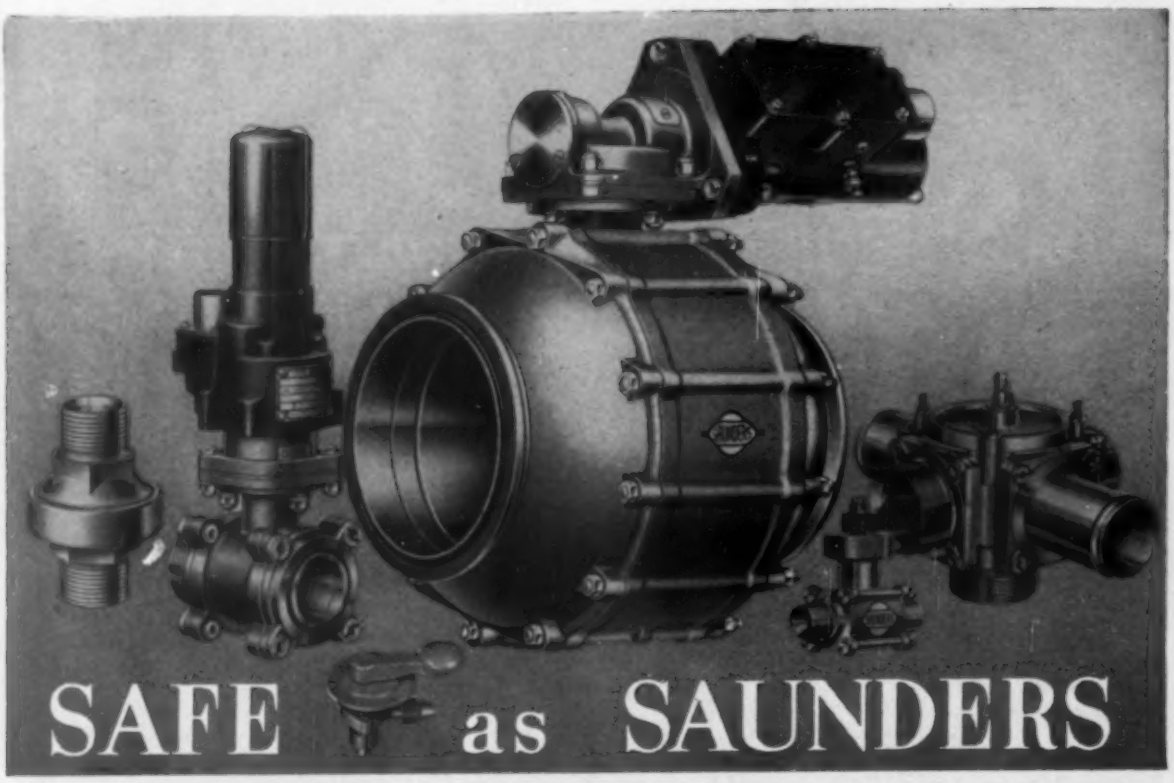

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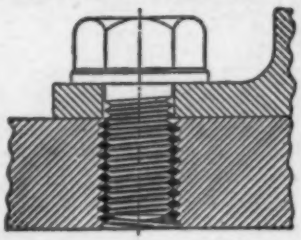

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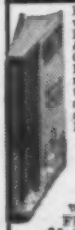

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APPLICATION No. 98/3. From Transair, Ltd., of Croydon Airport, Surrey, for an amendment to the terms of approval of the Seasonal U.K. Internal Service which they are authorised to operate for the period up to mid September 1959, on the route London (Croydon or Gatwick)-Guernsey/Jersey, so as to increase the present frequency of three return flights each Saturday to six return flights each Saturday during the period 8th June, 1957, to mid September, 1959.

APPLICATION No. 41/6. From Airlines (Jersey), Ltd., of The Parade, St. Helier, Jersey, C.I., for an amendment to the terms of approval of the Normal Scheduled Service which they are authorised to operate for the period up to 31st March, 1963, on the route Manchester (Ringway)-Coventry (Baginton)-Bournemouth (Hurn)-Guernsey and/or Jersey-Dinard-Rennes-La Baule and Nantes (optional) either additional or alternative to Dinard, Rennes and La Baule, so as to operate direct flights at the Company's discretion between Manchester and Jersey during the summer months for the remaining period of approval.

APPLICATION No. 835. From British European Airways Corporation, of Keyline House, Ruislip, Middlesex, for an All Freight Service with Leopard, Pionair, Elizabethan and Viscount aircraft for the carriage of freight between London Airport-Dusseldorf and/or Frankfurt and/or Stuttgart at a frequency of up to seven return flights weekly increasing further according to traffic demand during the period from October 1, 1956, to September 30, 1966.

THESE applications will be considered by the Council under the Terms of Reference issued to them by the Minister of Civil Aviation on July 30, 1952. Any representations or objections with regard to the applications must be made in writing stating the reasons and must reach the Council within 14 days of the date of this advertisement, addressed to the Secretary, Air Transport Advisory Council, 3, Dean's Yard, London, S.W.1, from whom further details of the applications may be obtained. When an objection is made to an application by another air transport company on the grounds that they are applying to operate the route or part of route in question, their application, if not already submitted to the Council, should reach them within the period allowed for the making of representations or objections. [5617

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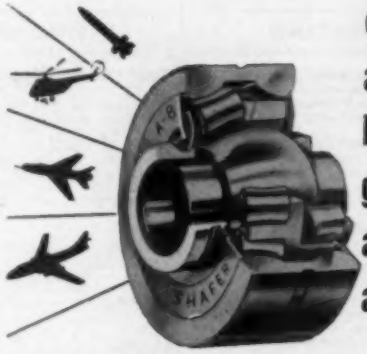

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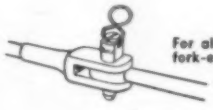

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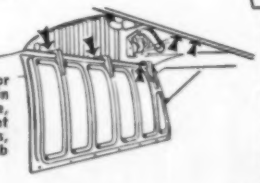

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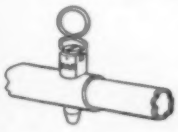

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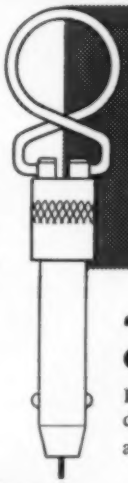

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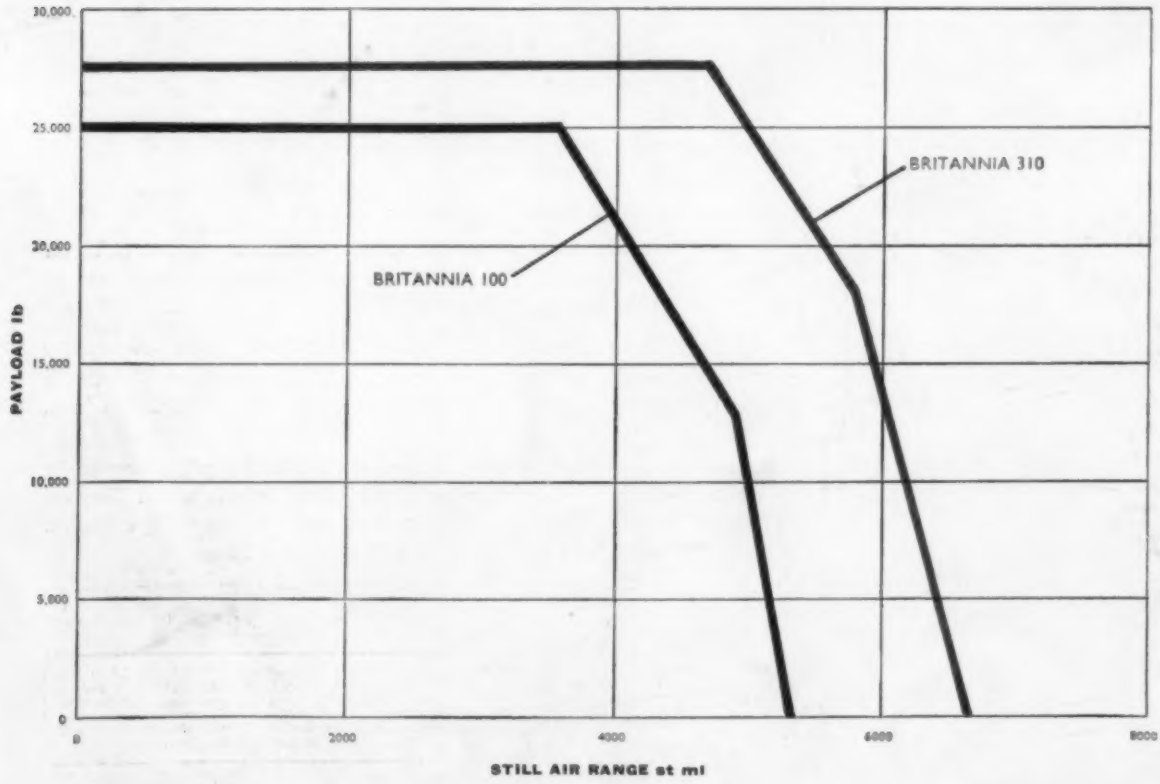

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